WIM System Field Calibration and Validation Summary Report

Kansas SPS-2
SHRP ID – 200200

Validation Date: December 22, 2010
Submitted: 1/7/2011

Table of Contents

List of Figures

List of Tables

1 Executive Summary

A WIM validation was performed on December 21 and 22, 2010 at the Kansas SPS-2 site located on route I-70 at milepost 287.5, 7.6 miles west of US 77.

This site was installed on June 08, 2006. The in-road sensors are installed in the westbound lane. The site is equipped with bending plate WIM sensors and IRD iSINC WIM controller. The LTPP lane is identified as lane 1 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on July 30, 2008 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

The equipment is in working order. Electronic and electrical checks of all WIM components determined that the equipment is operating within tolerances. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, no pavement deficiencies that would affect the performance of the WIM scales were noted. Observations of trucks passing over the site did not detect any motions by the trucks that would affect WIM system accuracies. Further pavement condition discussion is provided in Section 4.

Based on the criteria contained in the LTPP Field Operations Guide for SPS WIM Sites, Version 1.0 (05/09), this site is providing research quality loading data. The summary results of the validation are provided in Table 1-1 below.

Table 1-1 – Post-Validation Results – 22-Dec-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-0.2 ± 5.1%	Pass
Tandem Axles	±15 percent	-0.4 ± 3.4%	Pass
GVW	±10 percent	-0.3 ± 2.4%	Pass
Vehicle Length	±3 percent (1.9 ft)	-0.2 ± 1.1 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was -0.1 ± 1.6 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. Since the site is measuring axle spacing length with a mean error of -0.1 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly.

This site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 0.0% is within the 2.0% acceptability criterion for

LTPP SPS WIM sites. The overall misclassification rate of 1.0% from the 100 truck sample (Class 4 – 13) was due to one misclassification of Class 8 vehicle.

There were two test trucks used for the post-validation. They were configured and loaded as follows:

- The *Primary* truck was a Class 9 vehicle with air suspension on the tractor and trailer tandems, and standard (4 feet) tandem spacings. It was loaded with grain loaded evenly along the trailer.

- The *Secondary* truck was a Class 9 vehicle with air suspension on the tractor tandem, air on the trailer tandem, standard tandem spacing on the tractor and standard tandem on the trailer. The Secondary truck was loaded with grain loaded evenly along the trailer.

Prior to the validation, the test trucks were weighed and measured, cold tire pressures were taken, and photographs of the trucks, loads and suspensions were obtained (see Section 7). Axle length (AL) was measured from the center hub of the first axle to the center hub of the last axle. Overall length (OL) was measured from the edge of the front bumper to the edge of the rear bumper. The test trucks were re-weighed at the conclusion of the validation. The average post-validation test truck weights and measurements are provided in Table 1-2.

Table 1-2 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.9	11.0	16.7	16.9	15.3	15.9	19.5	4.3	31.2	4.0	59.0	63.5
2	65.1	10.9	14.9	15.0	12.2	12.2	19.5	4.3	31.6	4.0	59.4	64.0

The posted speed limit at the site is 70 mph. During the testing, the speed of the test trucks ranged from to 59 to 69 mph, a range of 10 mph.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 14.4 to 32.6 degrees Fahrenheit, a range of 18.2 degrees Fahrenheit. The mostly cloudy weather conditions prevented the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 24 shows that there are 34 consecutive months of level "E" WIM data for this site. This site requires at least 2 additional years of data to meet the minimum of five years of research quality data.

2 Pre-Visit Data Analysis

To assess the quality of the current data, a pre-visit analysis was conducted by comparing a two-week data sample from November 29, 2010 (Data) to the most recent Comparison Data Set (CDS) from August 01, 2008. The assessments performed prior to the site visits are used to develop reasonable expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 24 shows that there are 34 months of level "E" WIM data for this site. This site requires 3 additional years of data to meet the minimum of five years of research quality data.

As shown in Table 2-2, the 2006, 2007 and 2009 data does not meet the 210-day minimum requirement for a calendar year, however, the continuous data for the last 7 months of 2006 and the first 8 months of 2007 provide more than 210 days data, and therefore provide for a 12 month period for which 210 days of WIM data has been collected in addition to the 2008 data.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2006	199	7
2007	180	8
2008	361	12
2009	200	7

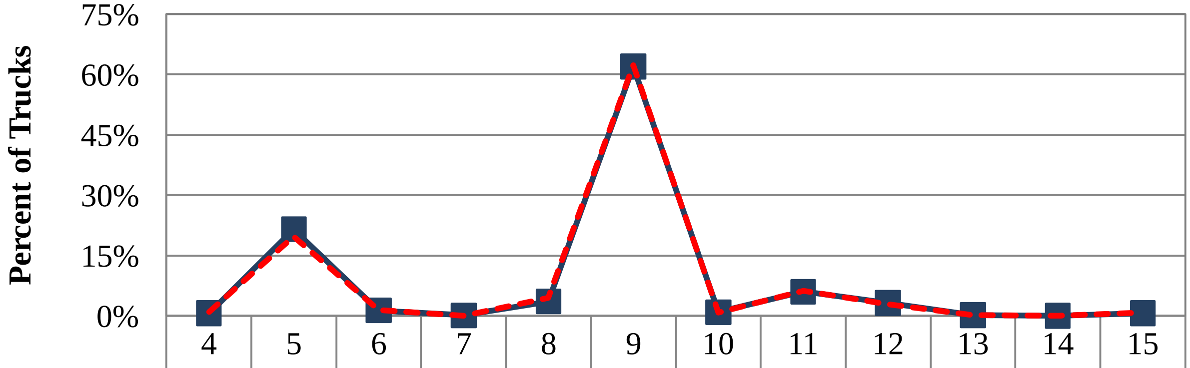
Table 2-2 provides a breakdown of the available data for years 2006 through 2009.

Table 2-2 – LTPP Data Availability by Month

	Number of Days in Month											
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006						19	31	31	30	31	29	28
2007	28	28	30	4					7	28	27	28
2008	31	29	31	30	31	29	31	31	30	31	26	31
2009	31	28	31	30	31	30	19					

2.2 Classification Data Analysis

The traffic data was analyzed to determine the expected truck distributions. This analysis provides a basis for the classification distribution study that was conducted on site. Figure 2-1 provides a comparison of the truck type distributions for the two datasets. From the figure it can be seen that the truck classification distributions for the August 2008 and November 2010 datasets are nearly identical.



	4	5	6	7	8	9	10	11	12	13	14	15
Data	0.7%	21.5%	1.3%	0.1%	3.5%	62.0%	0.9%	6.0%	3.2%	0.2%	0.0%	0.6%
CDS	1.0%	19.7%	1.5%	0.1%	4.5%	62.4%	0.8%	6.2%	2.9%	0.1%	0.0%	0.9%

Figure 2-1 – Comparison of Truck Distribution

Table 2-3 provides statistics for the truck distributions at the site for the two periods represented by the two datasets. The table shows that according to the most recent data, the most frequent truck types crossing the WIM scale are Class 9 (62.0%) and Class 5 (21.5%). It also indicates that 0.6 percent of the vehicles at this site are unclassified (Class 15). Table 2-3 also provides data for vehicle Classes 14 and 15. Class 14 vehicles are vehicles that are reported by the WIM equipment as having irregular measurements and cannot be classified properly, such as negative speeds from vehicles passing in the opposite direction of a two-lane road. Class 15 vehicles are unclassified vehicles.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	8/1/2008		11/29/2010		
4	277	1.0%	155	0.7%	-0.3%
5	5616	19.7%	5010	21.5%	1.8%
6	413	1.5%	313	1.3%	-0.1%
7	17	0.1%	24	0.1%	0.0%
8	1287	4.5%	826	3.5%	-1.0%
9	17742	62.4%	14455	62.0%	-0.3%
10	218	0.8%	209	0.9%	0.1%
11	1774	6.2%	1390	6.0%	-0.3%
12	827	2.9%	737	3.2%	0.3%
13	35	0.1%	38	0.2%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	246	0.9%	151	0.6%	-0.2%

From the table it can be seen that the number of Class 9 vehicles has decreased by 0.3 percent from August 2008 and November 2010. Small changes in the number of heavier trucks may be attributed to seasonal variations in truck distributions. During the same time period, the number of Class 5 trucks increased by 1.8 percent. These differences may be attributed to small sample size used to develop vehicle class distributions, changes in the use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes.

2.3 Speed Data Analysis

The traffic data received from the Phase II Contractor was analyzed to determine the expected truck speed distributions. This will provide a basis for determining the speed of the test trucks during validation testing. The CDS distribution of speeds is shown in Figure 2-2.

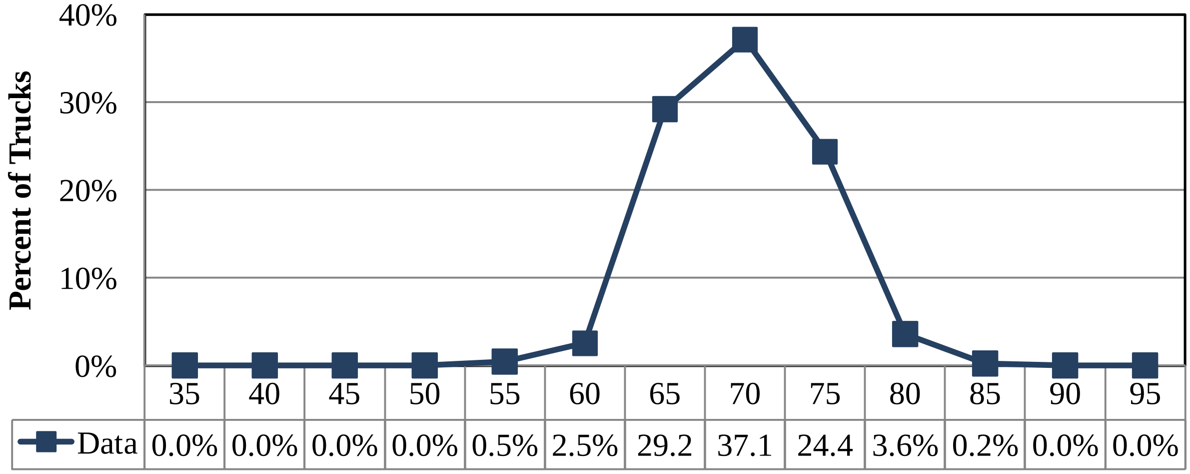


Figure 2-2 – Truck Speed Distribution – 10-Dec-10

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 65 and 70 mph. The posted speed limit at this site is 70 and the 85th percentile speed for trucks at this site is 72 mph. The coverage of truck speeds for the validation will be 60 and 70 mph. Since the 85th percentile speeds for trucks is above the posted speed limit, the post-visit applied calibration will be used to develop compensation factors for speed points from 65 to 75 mph.

2.4 GVW Data Analysis

The traffic CDS data received from the Regional Support Contractor was analyzed to determine the expected Class 9 GVW distributions. Figure 2-3 shows a comparison between GVW plots generated using a two-week W-card sample from November 2010 and the Comparison Data Set from August 2008.

As shown in Figure 2-3, the unloaded and loaded peaks for the August 2008 Comparison Data Set (CDS) and the November 2010 two-week sample W-card dataset (Data) are similar.

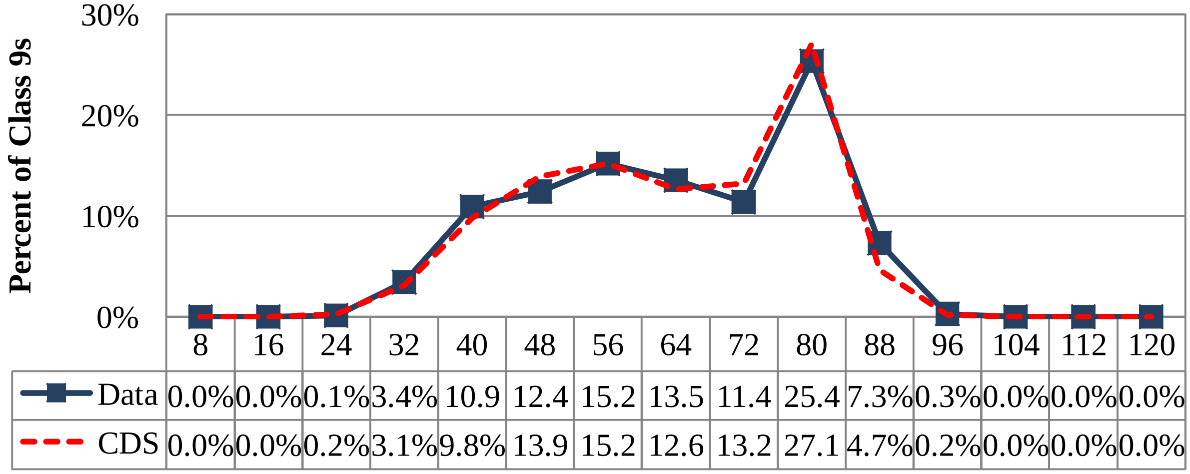


Figure 2-3 – Comparison of Class 9 GVW Distribution

Table 2-4 is provided to show the statistical comparison between the Comparison Data Set and the current dataset.

Table 2-4 – Class 9 GVW Distribution from W-Card

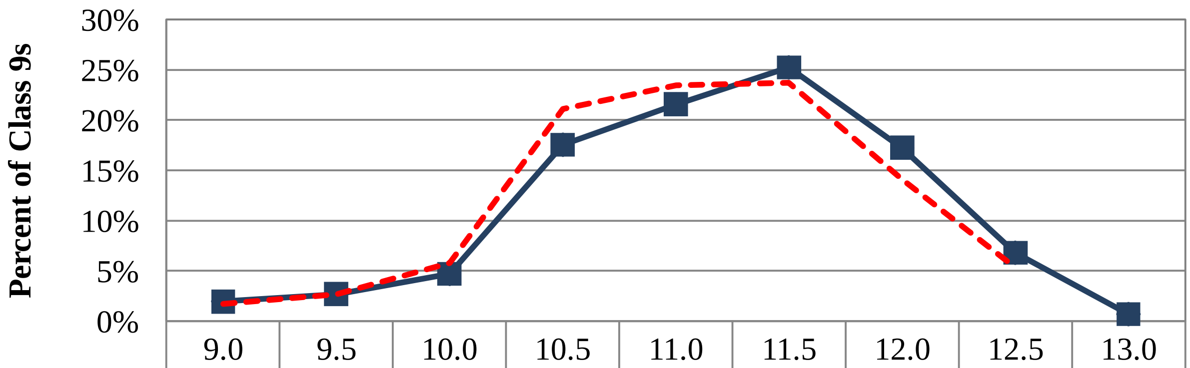
GVW weight bins (kips)	CDS		Data		Change
	Date				
	8/1/2008		11/29/2010		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	41	0.2%	20	0.1%	-0.1%
32	547	3.1%	495	3.4%	0.3%
40	1721	9.8%	1576	10.9%	1.2%
48	2456	13.9%	1789	12.4%	-1.5%
56	2681	15.2%	2189	15.2%	0.0%
64	2228	12.6%	1949	13.5%	0.9%
72	2331	13.2%	1639	11.4%	-1.8%
80	4772	27.1%	3656	25.4%	-1.7%
88	823	4.7%	1053	7.3%	2.6%
96	31	0.2%	39	0.3%	0.1%
104	0	0.0%	1	0.0%	0.0%
112	0	0.0%	1	0.0%	0.0%
120	0	0.0%	0	0.0%	0.0%
Average =	59.7		59.9		0.2

As shown in the table, the number of unloaded class 9 trucks in the 32 to 40 kips range increased by 1.2 percent while the number of loaded class 9 trucks in the 72 to 80 kips range decreased by 1.7 percent. The number of overweight trucks (greater than 80 kips) increased during this time period by 2.7 percent and the overall GVW average for this site increased from 59.7 kips to 59.9 kips.

2.5 Class 9 Front Axle Weight Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average front axle weight. This will provide a basis for the evaluation of the quality of the data by comparing the average front axle weight from the most current dataset with the expected average front axle weight average from the comparison dataset.

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from November 2010 and the Comparison Data Set from August 2008.



	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Data	2.0%	2.7%	4.7%	17.5%	21.6%	25.2%	17.2%	6.8%	0.7%
CDS	1.7%	2.6%	5.8%	21.1%	23.5%	23.7%	14.1%	5.4%	

Figure 2-4 – Distribution of Class 9 Front Axle Weights

It can be seen in the figure that there is a slight shift to the right between the August 2008 Comparison Data Set (CDS) and the November 2010 dataset (Data), indicating an increase in the front axle weights of Class 9 trucks.

Table 2-5 provides the Class 9 front axle weight distribution data for the August 2008 Comparison Data Set (CDS) and the November 2010 dataset (Data).

Table 2-5 – Class 9 Front Axle Weight Distribution from W-Card

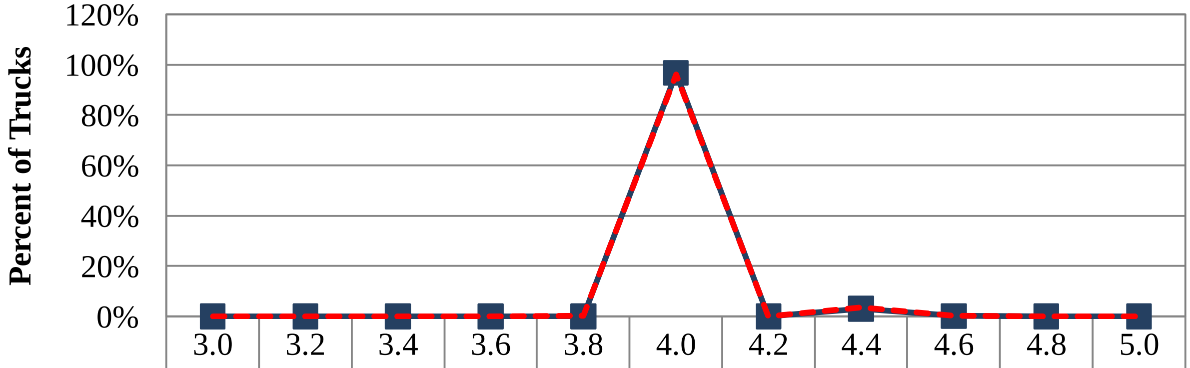
F/A weight bins (kips)	CDS		Data		Change
	Date				
	8/1/2008		11/29/2010		
9.0	279	1.6%	230	1.6%	0.0%
9.5	305	1.7%	280	2.0%	0.2%
10.0	464	2.6%	386	2.7%	0.0%
10.5	1013	5.8%	673	4.7%	-1.1%
11.0	3697	21.1%	2515	17.5%	-3.5%
11.5	4117	23.5%	3094	21.6%	-1.9%
12.0	4159	23.7%	3621	25.2%	1.5%
12.5	2472	14.1%	2474	17.2%	3.2%
13.0	939	5.4%	975	6.8%	1.4%
13.5	93	0.5%	98	0.7%	0.2%
Average =	11.3		11.4		0.1

The table shows that the average front axle weight for Class 9 trucks has increased by 0.1 kips, or 0.7 percent. According to the current data, the bin with the highest number of the Class 9 front axle weights is between 11.5 and 12.0 kips, and the average front axle weight for Class 9 trucks is 11.4 kips. 0.9% heavier than the average front axle weight from the Comparison Data Set.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average tractor tandem spacing. This will provide a basis for the evaluation of the accuracy of the equipment distance and speed measurements by comparing the average drive tandem spacing from the most current dataset with the expected average drive tandem spacing from the comparison dataset.

The class 9 tractor tandem spacing plots in Figure 2-5 are provided to indicate possible shifts in WIM system distance and speed measurement accuracies.



	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Data	0.0%	0.0%	0.0%	0.0%	0.1%	96.7%	0.0%	3.1%	0.2%	0.0%	0.0%
CDS	0.0%	0.0%	0.0%	0.0%	0.2%	96.1%	0.0%	3.5%	0.2%	0.0%	0.0%

Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacing for the August 2008 Comparison Data Set and the November 2010 Data are nearly identical, indicating that the distance and speed accuracy of the equipment has not changed.

Table 2-6 shows the Class 9 axle spacings between the second and third axles for the power unit.

Table 2-6 – Class 9 Axle 3 to 4 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	8/1/2008		11/29/2010		
3.0	0	0.0%	0	0.0%	0.0%
3.2	7	0.0%	0	0.0%	0.0%
3.4	6	0.0%	2	0.0%	0.0%
3.6	0	0.0%	0	0.0%	0.0%
3.8	32	0.2%	8	0.1%	-0.1%
4.0	16943	96.1%	13933	96.7%	0.6%
4.2	0	0.0%	0	0.0%	0.0%
4.4	613	3.5%	442	3.1%	-0.4%
4.6	30	0.2%	22	0.2%	0.0%
4.8	0	0.0%	0	0.0%	0.0%
5.0	0	0.0%	0	0.0%	0.0%
Average =	4.0		4.0		0.0

From the table it can be seen that the spacings of the tractor tandems for Class 9 trucks at this site are between 3.8 and 4.6 feet. The average tractor tandem spacing for the most recent dataset is 4.0 feet, which is identical to the expected average from the Comparison Data Set.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (August 2008) based on the last calibration with the most recent two-week WIM data sample from the site (November 2010). Comparison of vehicle class distribution data indicates a 0.3 percent decreased in the number of Class 9 vehicles. Analysis of Class 9 weight data indicates that front axle weights have increased by 0.1 percent and average Class 9 GVW has increased by 0.3 percent for the November 2010 data. The data indicates an average truck tandem spacing of 4.0 feet, which is identical to the expected average from the Comparison Data Set.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on July 30, 2008 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on June 08, 2006 by International Road Dynamics. It is instrumented with bending plate weighing sensors and IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

Prior to the pre-validation test truck runs, a physical inspection of all WIM equipment and support services equipment was conducted. No deficiencies were noted. Photographs of all system components were collected and are presented in the Appendix that follows Section 7.

3.3 Electronic and Electrical Testing

Electronic and electrical checks of all system components were conducted prior to the pre-validation test truck runs. Dynamic and static electronic checks of the in-road sensors were performed with no sensor deficiencies noted. All values for the WIM sensors and inductive loops were within tolerances. Electronic tests of the power and communication devices indicated that they were operating normally.

3.4 Equipment Troubleshooting and Diagnostics

The WIM system appeared to collect, analyze and report vehicle measurements normally. No troubleshooting actions were taken.

3.5 Recommended Equipment Maintenance

No equipment maintenance actions are recommended.

4 Pavement Discussion

4.1 Pavement Condition Survey

During a visual distress survey of the pavement conducted from the shoulder, no areas of pavement distress that may affect the accuracy of the WIM sensors were noted.

4.2 Profile and Vehicle Interaction

Profile data was collected on October 19, 2010 by the North Central Regional Support Contractor using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, beginning 900 feet prior to WIM scales and ending 100 feet after the WIM scales. Each pass collects International Roughness Index (IRI) values in both the left and right wheel paths. For this site, 11 profile passes were made, 5 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section is 170 in/mi and is located approximately 524 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 139 in/mi and is located approximately 333 feet prior to the WIM scale. This area of pavement was closely investigated during the validation visit, and truck dynamics in this area were closely observed. There were no distresses observed that would influence truck dynamics in the WIM scale area.

Additionally, a visual observation of the trucks as they approach, traverse and leave the sensor area did not indicate any visible motion of the trucks that would affect the performance of the WIM scales. Trucks appear to track down the center of the lane.

4.3 LTPP Pavement Profile Data Analysis

The IRI data files are processed using the WIM Smoothness Index software. The indices produced by the software provide an indication of whether or not the pavement roughness may affect the operation of the WIM equipment. The recommended thresholds for WIM Site pavement smoothness are provided in Table 4-1.

Table 4-1 – Recommended WIM Smoothness Index Thresholds

Index	Lower Threshold (m/km)	Upper Threshold (m/km)
Long Range Index (LRI)	0.50	2.1
Short Range Index (SRI)	0.50	2.1
Peak LRI	0.50	2.1
Peak SRI	0.75	2.9

When all values are less than the lower threshold shown in Table 4-1, it is unlikely that pavement conditions will significantly influence sensor output. Values between the threshold values may or may not influence the accuracy of the sensor output and values above the upper threshold would lead to sensor output that would preclude achieving the research quality loading data.

The profile analysis was based on four different indices: Long Range Index (LRI), which represents the pavement roughness starting 25.8 m prior to the scale and ending 3.2 m after the scale in the direction of travel; Short Range Index (SRI), which represents the pavement roughness beginning 2.74 m prior to the WIM scale and ending 0.46 m after the scale; Peak LRI – the highest value of LRI within 30 m prior to the scale; and Peak SRI – the highest value of SRI between 2.45 m prior to the scale and 1.5 m after the scale. The results from the analysis for each of the indices for the right wheel path (RWP) and left wheel path (LWP) values for the 3 left, 3 right and 5 center profiler runs are presented in Table 4-2.

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Pass5**	**Avg**
Left	LWP	LRI (m/km)	1.712	1.541	1.401			1.551
		SRI (m/km)	0.817	0.603	0.808			0.743
		Peak LRI (m/km)	2.001	1.650	1.909			1.853
		Peak SRI (m/km)	1.765	0.810	1.317			1.297
	RWP	LRI (m/km)	1.017	0.924	0.980			0.974
		SRI (m/km)	0.879	0.626	0.833			0.779
		Peak LRI (m/km)	1.036	1.019	1.010			1.022
		Peak SRI (m/km)	1.030	0.844	0.949			0.941
Center	LWP	LRI (m/km)	0.787	0.893	0.788	0.783	0.873	0.813
		SRI (m/km)	0.615	0.669	0.537	0.748	0.990	0.642
		Peak LRI (m/km)	0.811	0.923	1.000	0.917	0.949	0.913
		Peak SRI (m/km)	1.022	0.852	0.933	0.802	1.129	0.902
	RWP	LRI (m/km)	0.652	1.132	1.044	1.030	0.872	0.965
		SRI (m/km)	0.519	1.016	0.762	1.085	0.733	0.846
		Peak LRI (m/km)	0.984	1.254	1.348	1.148	1.051	1.184
		Peak SRI (m/km)	*0.654*	1.169	1.107	1.166	0.833	1.024
Right	LWP	LRI (m/km)	1.022	0.732	1.210			0.988
		SRI (m/km)	1.140	0.961	0.867			0.989
		Peak LRI (m/km)	1.185	0.954				1.070
		Peak SRI (m/km)	1.262	1.069	1.111			1.147
	RWP	LRI (m/km)	0.846	0.726	0.954			0.842
		SRI (m/km)	1.032	0.942	0.881			0.952
		Peak LRI (m/km)	0.981	1.106	1.029			1.039
		Peak SRI (m/km)	1.189	0.945	1.041			1.058

From Table 4-2 it can be seen that most of the indices computed from the profiles are between the upper and lower threshold values, with the remaining values under the lower threshold. The highest values, on average, are the Peak LRI values in the left wheel path of the left shift passes..

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

The following section provides summaries of data collected during the pre-validation, the calibration, and the post-validation test truck runs, as well as information resulting from the classification and speed studies. All analyses of test truck data and information on necessary equipment adjustments are provided.

5.1 Pre-Validation

The first set of test runs provides a general overview of system performance prior to any calibration adjustments for the given environmental, vehicle speed and other conditions.

The 40 pre-validation test truck runs were conducted on December 21, 2010, beginning at approximately 7:55 AM and continuing until 2:13 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with grain loaded evenly along the trailer, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.

- A Class 9, 5-axle truck, loaded with grain loaded evenly along the trailer, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the pre-validation and were re-weighed at the conclusion of the pre-validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 - Pre-Validation Test Truck Weights and Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	76.5	11.1	16.1	17.0	15.5	16.8	19.5	4.3	31.2	4.0	59.0	63.5
2	66.1	10.8	13.7	13.3	14.0	14.3	19.5	4.3	31.6	4.0	59.4	64.0

Test truck speeds varied by 10 mph, from 59 to 69 mph. The measured pre-validation pavement temperatures varied 21.5 degrees Fahrenheit, from 22.5 to 44.0. The mostly cloudy weather conditions prevented the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

Table 5-2 – Pre-Validation Overall Results – 21-Dec-10

Parameter	**95% Confidence Limit of Error**	**Site Values**	**Pass/Fail**
Steering Axles	±20 percent	1.6 ± 5.1%	Pass
Tandem Axles	±15 percent	2.7 ± 3.1%	Pass
GVW	±10 percent	2.5 ± 2.2%	Pass
Vehicle Length	±3 percent (1.9 ft)	2.2 ± 0.9 ft	FAIL
Vehicle Speed	± 1.0 mph	0.2 ± 0.7 mph	Pass
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement over all speeds was 0.2 ± 0.7 mph, which is within the ±1.0 mph tolerance established by the LTPP Field Guide. Since the site is measuring axle spacing length with a mean error of -0.1, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 70 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3 below.

Table 5-3 – Pre-Validation Results by Speed – 21-Dec-10

Parameter	**95% Confidence Limit of Error**	**Low**	**Medium**	**High**
		59.0 to 62.3 mph	**62.4 to 65.8 mph**	**65.9 to 69.0 mph**
Steering Axles	±20 percent	2.8 ± 6.6%	2.0 ± 4.0%	-0.1 ± 3.7%
Tandem Axles	±15 percent	3.2 ± 3.3%	2.6 ± 2.6%	2.3 ± 2.9%
GVW	±10 percent	3.1 ± 2.9%	2.5 ± 1.7%	1.9 ± 1.6%
Vehicle Length	±3 percent (1.9 ft)	2.3 ± 0.7 ft	2.3 ± 1.2 ft	2.1 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.2 ± 1.0 mph	0.1 ± 0.8 mph	0.1 ± 0.6 mph
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.4 ft	-0.1 ± 0.4 ft	-0.1 ± 0.3 ft

From the table, it can be seen that the overestimation of all weights appears to decrease as speed increases. The range of errors appears to generally get smaller as speed increases.

To aid in the speed analysis, several graphs were developed to illustrate the possible effects of speed on GVW, single axle, and axle group weights, and axle and overall length distance measurements, as discussed in the following sections.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment overestimates GVW at all speeds. The overestimation appears to decrease as speed increases. The range in error and bias is greater at the low speeds when compared with the medium and high speeds.

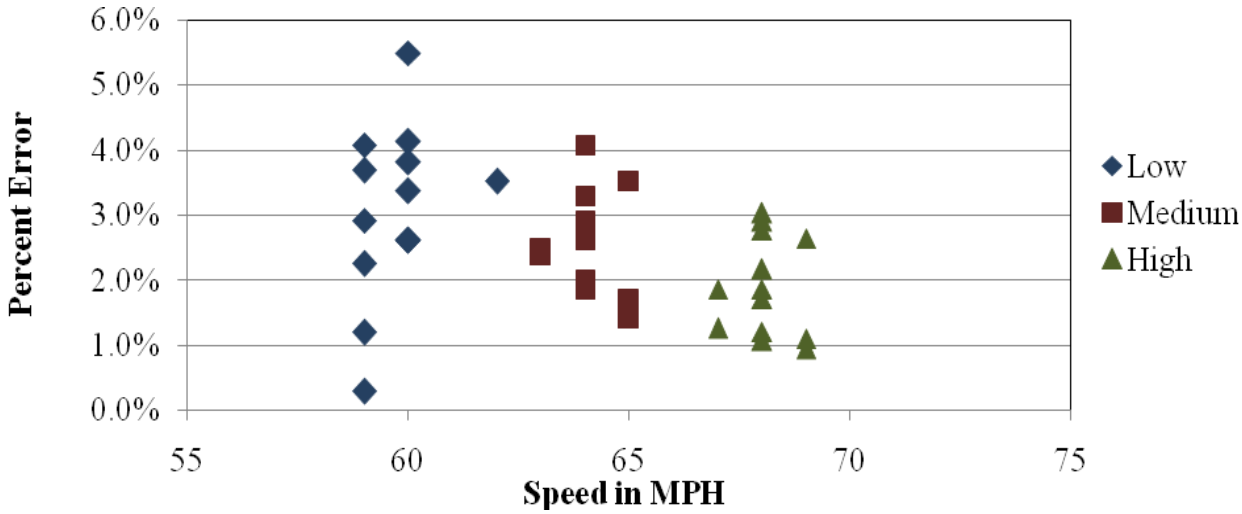


Figure 5-1 – Pre-Validation GVW Error by Speed – 21-Dec-10

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment overestimates steering axle weights at the low and medium speeds. The range in error appears to be greater at the lower speeds.

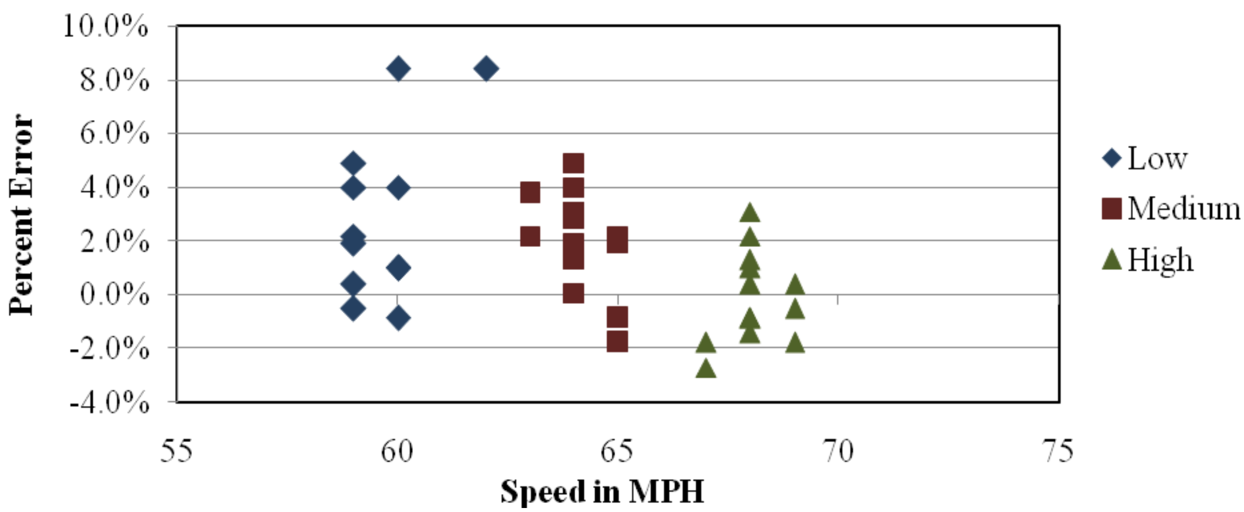


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 21-Dec-10

5.1.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-3, the equipment overestimates tandem axle weights with similar bias at all speeds. The range in error is similar throughout the entire speed range.

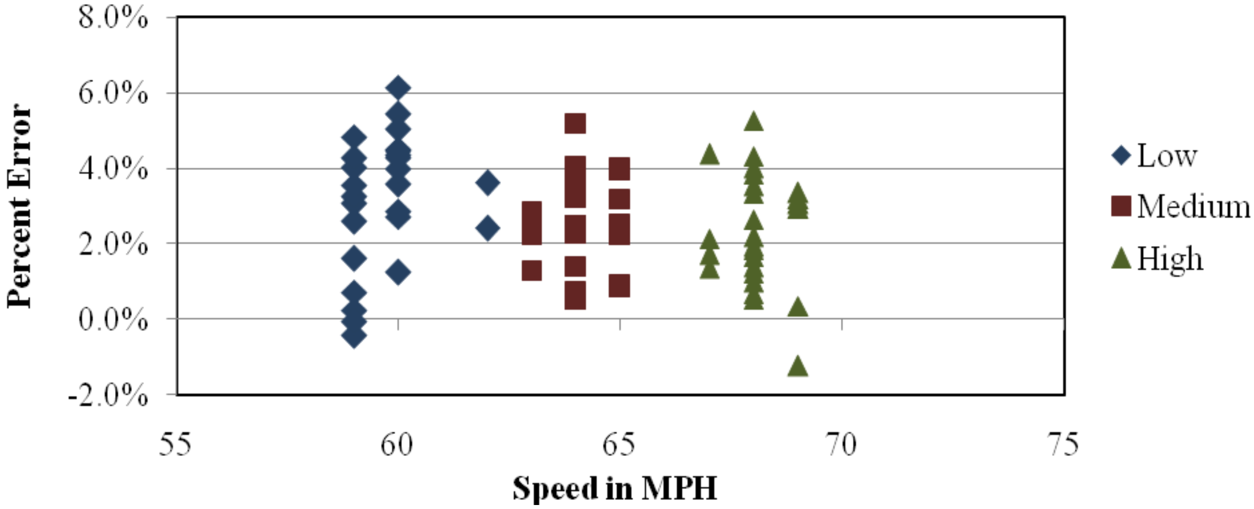


Figure 5-3 – Pre-Validation Tandem Axle Weight Errors by Speed – 21-Dec-10

5.1.1.4 GVW Errors by Speed and Truck Type

As shown in Figure 5-4, when the GVW error for each truck is analyzed as a function of speed, it can be seen that at the medium and high speeds, the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. The range in GVW estimation error for the Primary truck is greater at the low and high speeds.

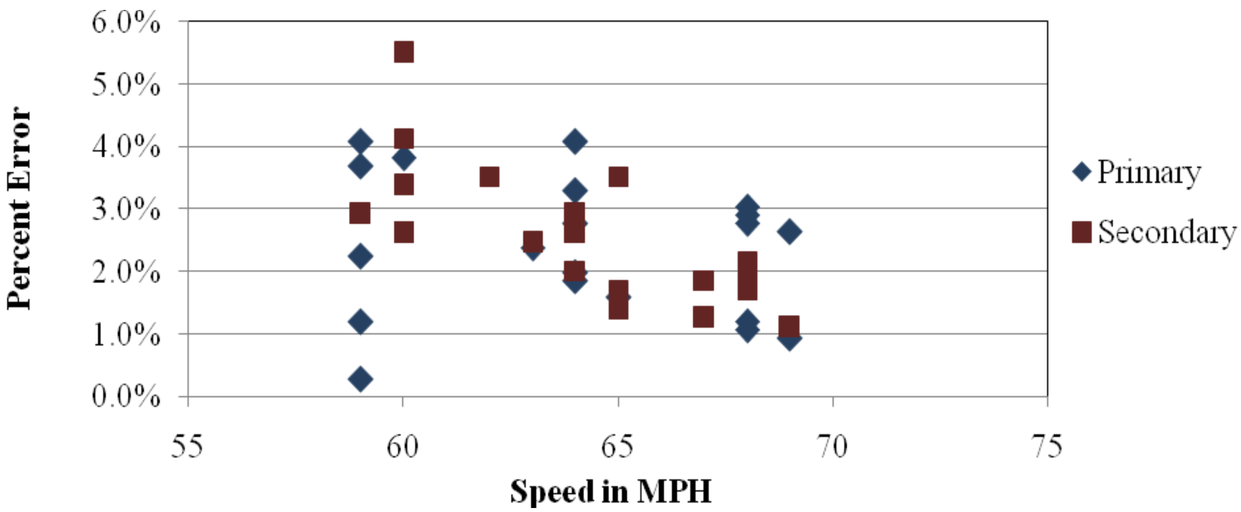


Figure 5-4 – Pre-Validation GVW Errors by Truck and Speed – 21-Dec-10

5.1.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error ranged from -0.4 feet to 0.3 feet. Distribution of errors is shown graphically in Figure 5-5.

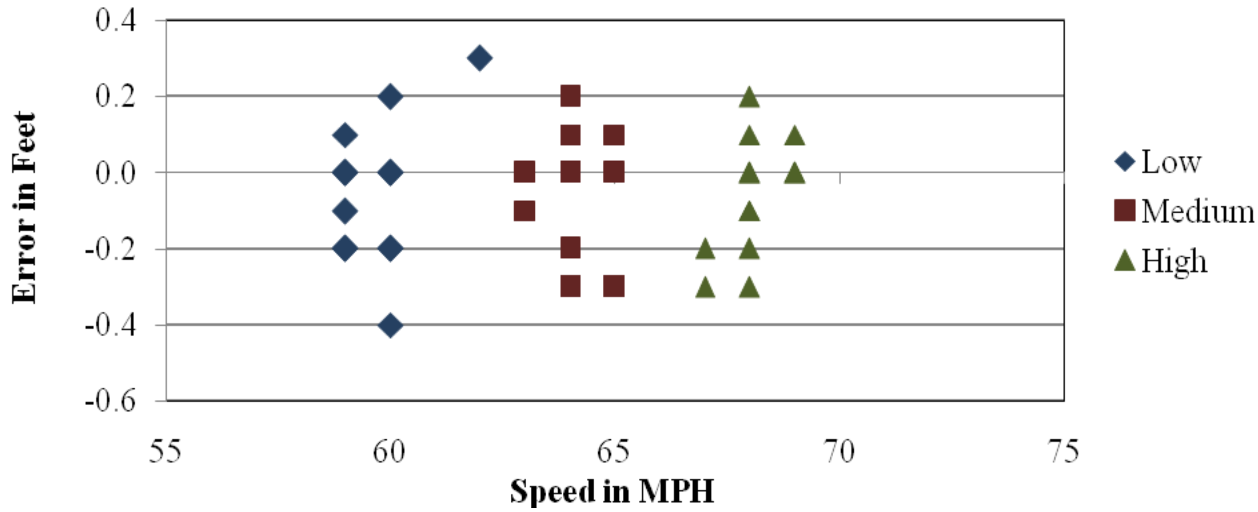


Figure 5-5 – Pre-Validation Axle Length Errors by Speed – 21-Dec-10

5.1.1.6 Overall Length Errors by Speed

For this system, the WIM equipment measured overall vehicle length consistently over the entire range of speeds, with an error range of 1.0 to 3.5 feet. Distribution of errors is shown graphically in Figure 5-6.

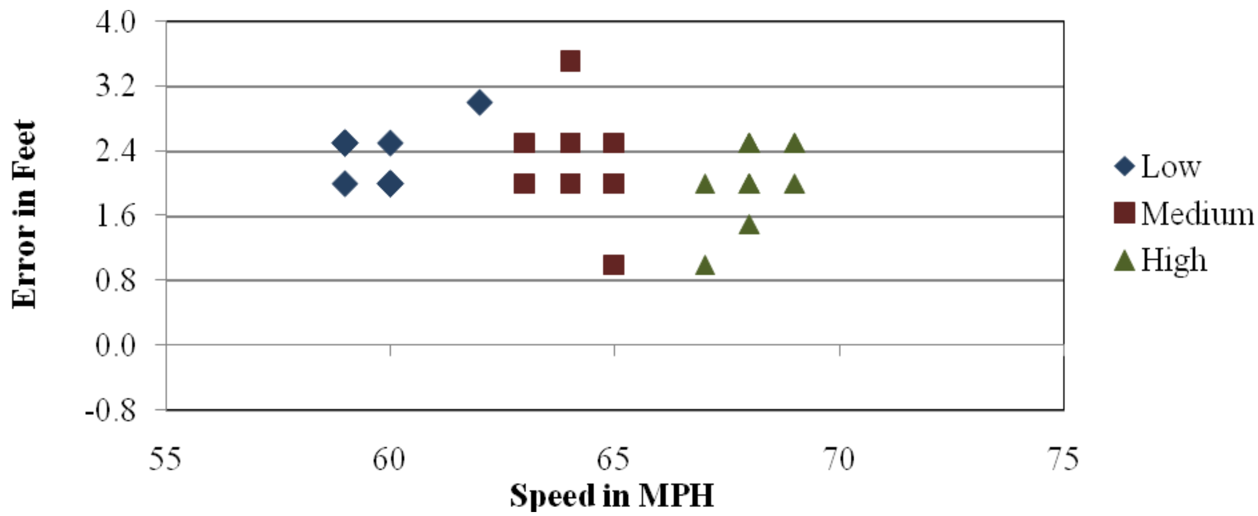


Figure 5-6 – Pre-Validation Overall Length Error by Speed – 21-Dec-10

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether there is a relation between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied 21.5 degrees, from 22.5 to 44.0 degrees Fahrenheit. The pre-validation test runs are being reported under two temperature groups as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 21-Dec-10

Parameter	95% Confidence Limit of Error	Low	High
		22.5 to 33.3 degF	33.4 to 44.1 degF
Steering Axles	±20 percent	2.6 ± 4.4%	0.8 ± 5.4%
Tandem Axles	±15 percent	2.8 ± 3.3%	2.6 ± 3.1%
GVW	±10 percent	2.8 ± 2.1%	2.2 ± 2.3%
Vehicle Length	±3 percent (1.9 ft)	2.4 ± 0.9 ft	2.1 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.2 ± 0.8 mph	0.1 ± 0.7 mph
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.4 ft	-0.1 ± 0.4 ft

To aid in the analysis, several graphs were developed to illustrate the possible effects of temperature on GVW, single axle, and axle group weights.

5.1.2.1 GVW Errors by Temperature

From Figure 5-7, it can be seen that the equipment appears to overestimate GVW across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and GVW estimates.

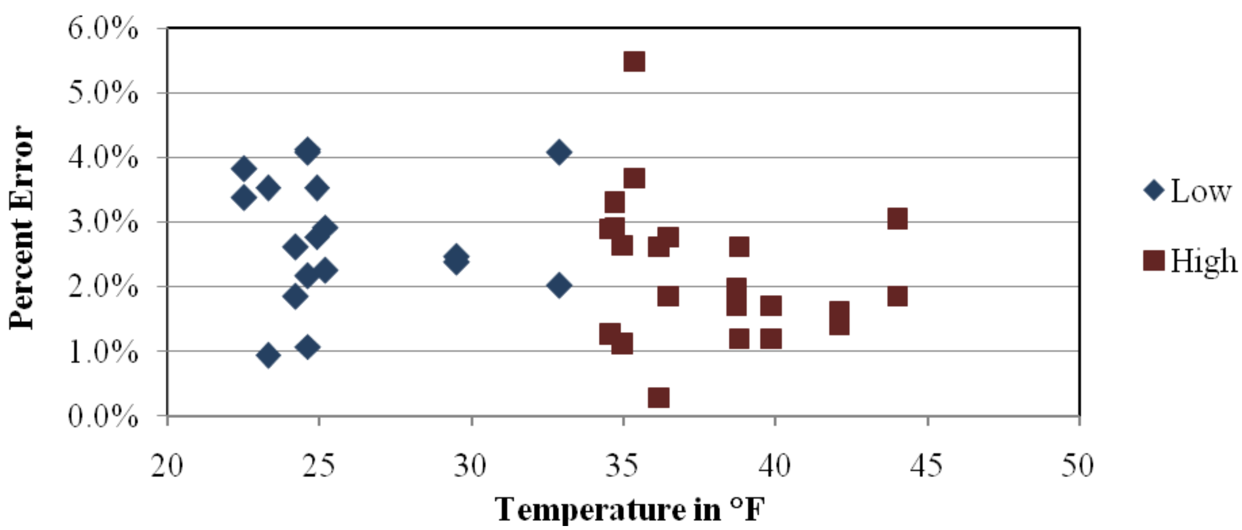


Figure 5-7 – Pre-Validation GVW Errors by Temperature – 21-Dec-10

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-8 shows that for loaded steering axles, the WIM equipment appears to demonstrate a trend where as the temperature rises, the overestimation of steering axle weight decreases. The range in error is similar for different temperature groups.

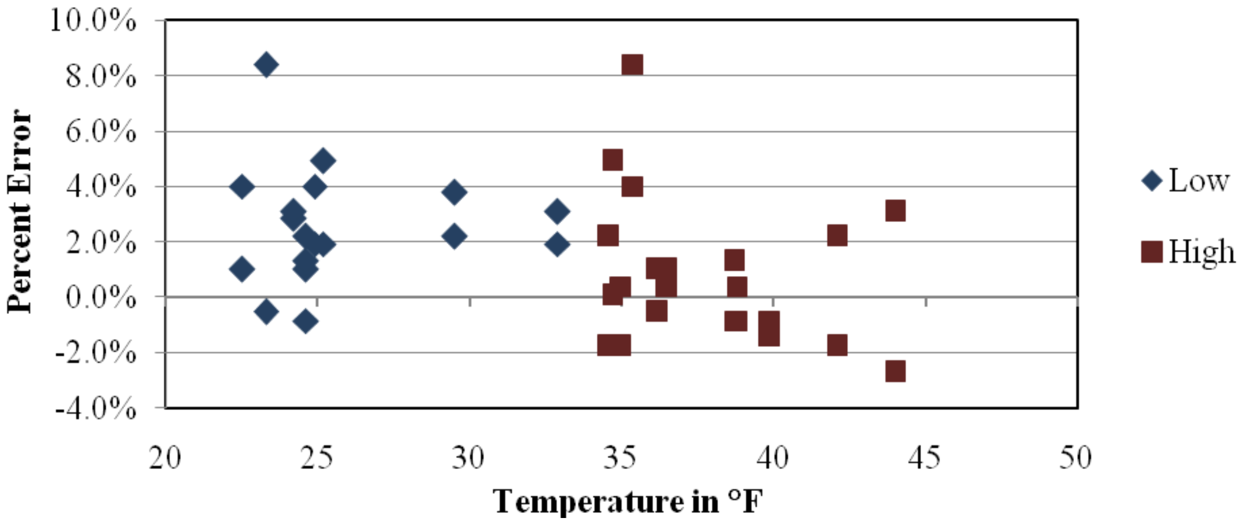


Figure 5-8 – Pre-Validation Steering Axle Weight Errors by Temperature – 21-Dec-10

5.1.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-9, the equipment consistently overestimates tandem axle weights over the range of temperatures. The range in error is consistent for the two temperature groups.

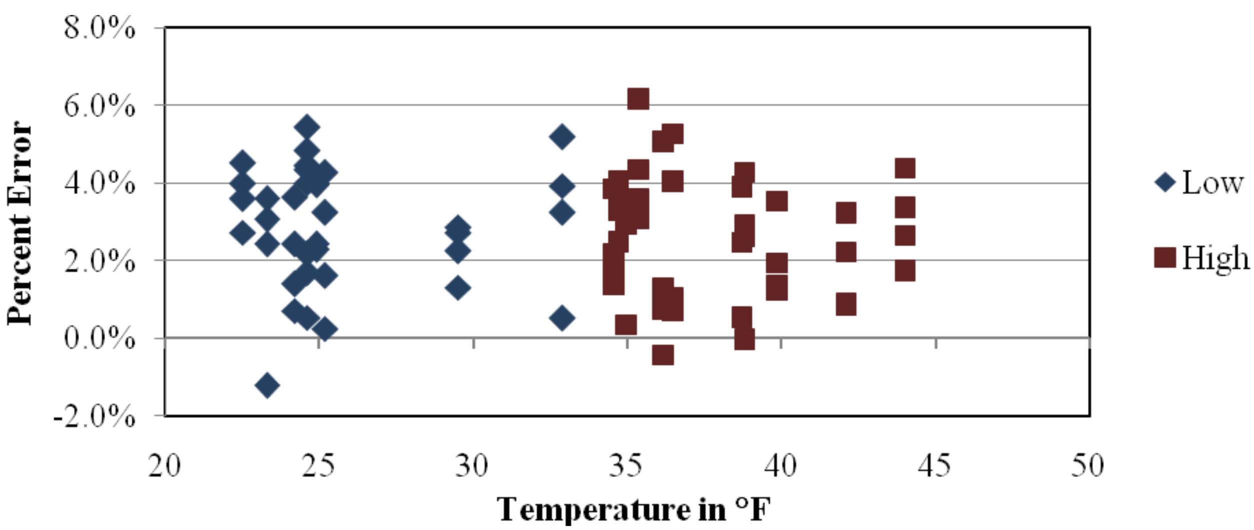


Figure 5-9 – Pre-Validation Tandem Axle Weight Errors by Temperature – 21-Dec-10

5.1.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-10, when analyzed for each test truck, GVW measurement errors and the range of errors for both trucks are similar across the range of temperatures.

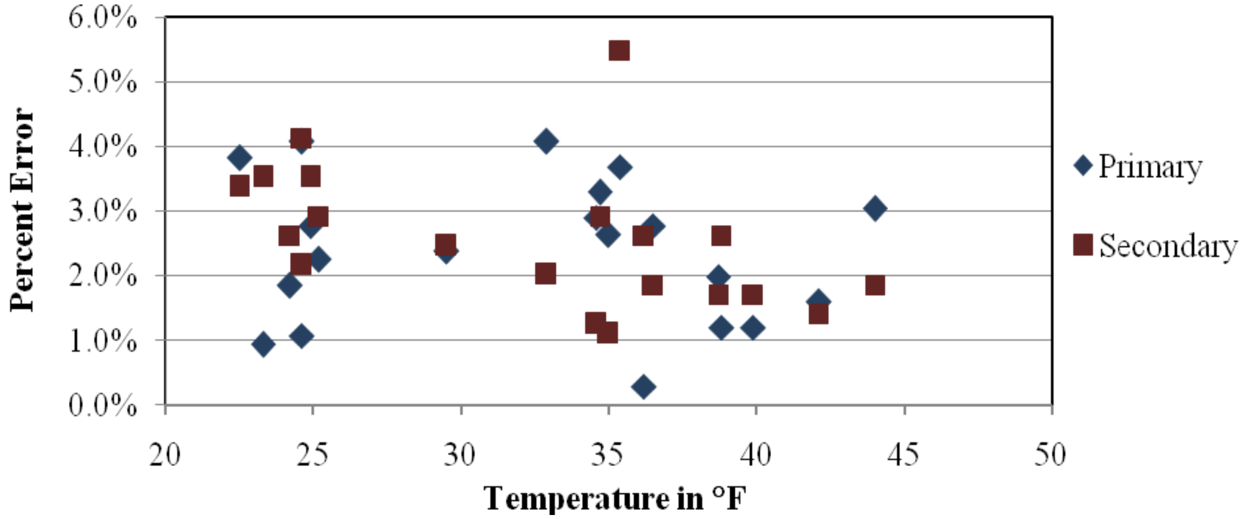


Figure 5-10 – Pre-Validation GVW Error by Truck and Temperature – 21-Dec-10

5.1.3 Classification and Speed Evaluation

The pre-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the pre-validation classification study at this site, a manual sample of 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field. Table 5-5 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-5 – Pre-Validation Classification Study Results – 21-Dec-10

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	0	15	2	0	9	70	1	2	1	0
WIM Count	0	16	2	0	8	70	1	2	1	0
Observed Percent	0	15	2	0	9	70	1	2	1	0
WIM Percent	0	16	2	0	8	70	1	2	1	0
Misclassified Count	0	0	0	0	1	0	0	0	0	0
Misclassified Percent	N/A	0	0	N/A	11	0	0	0	0	N/A
Unclassified Count	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	N/A	0	0	N/A	0	0	0	0	0	N/A

In the table above, the Misclassified count represents the number of vehicles of a particular class that were visually observed as that class, but were not classified as the same type of vehicle by the equipment. As shown in the table, one class 8 vehicle was identified by the WIM equipment as a Class 5 vehicle, resulting in an undercount by the WIM equipment of one Class 8 vehicle and an overcount of one Class 5 vehicle – a misclassification of one Class 8 vehicle.

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class of vehicle. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-6.

Table 5-6 – Pre-Validation Misclassifications by Pair – 21-Dec-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	0	5/9	0	9/5	0
3/8	0	6/4	0	9/8	0
4/5	0	6/7	0	9/10	0
4/6	0	6/8	0	10/9	0
5/3	0	6/10	0	10/13	0
5/4	0	7/6	0	11/12	0
5/6	0	8/3	0	12/11	0
5/7	0	8/5	1	13/10	0
5/8	0	8/9	0	13/11	0

Based on the vehicles observed during the pre-validation study, the misclassification percentage is 1.3% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 1.0%.

As shown in the table, a total of one Class 8 vehicle was misclassified as a Class 5 by the equipment. The cause of the misclassification was not investigated in the field.

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-7.

Table 5-7 – Pre-Validation Unclassified Trucks by Pair – 21-Dec-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	0		

Based on the manually collected sample of the 100 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was -0.2 mph; the range of errors was 1.6 mph.

5.2 Calibration

The WIM equipment required one calibration iteration between the pre- and post-validations. Information regarding the basis for changing equipment compensation factors, supporting data for the changes, and the resulting WIM accuracies from the calibrations are provided in this section.

The operating system weight compensation parameters that were in place prior to the pre-validation are shown in Table 5-8.

Table 5-8 – Initial System Parameters – 22-Dec-10

Speed Point	MPH	Left	Right
88	55	3258	3772
96	60	3494	4049
104	65	3428	3971
112	70	3440	3986
120	75	3509	4064
Axle Distance (cm)		370	
Dynamic Comp (%)		100	

5.2.1 Calibration Iteration 1

5.2.1.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall error of 2.5% and errors of 3.2%, 2.5%, and 2.1% at the 60, 65 and 70 mph speed points respectively. The errors for 60 mph and 70 mph speeds were extrapolated to derive new compensation factors for the 55 and 75 mph speed points. To compensate for these errors, the changes shown in Table 5-9 were made to the compensation factors.

Table 5-9 – Calibration 1 Equipment Factor Changes – 22-Dec-10

Speed Points	Old Factors		Error	New Factors	
	Left	Right		Left	Right
88	3258	3772	3.22%	3156	3654
96	3494	4049	3.22%	3385	3923
104	3428	3971	2.50%	3344	3874
112	3440	3986	2.09%	3370	3905
120	3509	4064	2.09%	3437	3981
Axle Distance (cm)	370		0.11%	370	
Dynamic Comp (%)	100		1.58%	101	

5.2.1.2 Calibration 1 Results

The results of the 14 first calibration verification runs are provided in Table 5-10. As can be seen in the table, the mean error of all weight estimates was reduced as a result of the first calibration iteration.

Table 5-10 – Calibration 1 Results – 22-Dec-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-1.1 ± 5.5%	Pass
Tandem Axles	±15 percent	-1.0 ± 3.2%	Pass
GVW	±10 percent	-1.0 ± 2.4%	Pass
Vehicle Length	±3 percent (1.9 ft)	0.1 ± 1.0 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.4 ft	Pass

Based on the results of the first calibration, where weight estimate bias decreased to less than 2.0 percent, a second calibration was not considered to be necessary. The 14 calibration runs were combined with 26 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 40 post-validation test truck runs were conducted on December 22, 2010, beginning at approximately 7:28 AM and continuing until 1:44 PM.

The two test trucks consisted of:

- A Class 9 truck, evenly loaded with grain, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.

- A Class 9, 5-axle truck, evenly loaded with grain and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and standard tandem spacing on the trailer.

The test trucks were weighed prior to the post-validation and re-weighed at the conclusion of the post-validation. The average test truck weights and measurements are provided in Table 5-11.

Table 5-11 - Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	75.9	11.0	16.7	16.9	15.3	15.9	19.5	4.3	31.2	4.0	59.0	63.5
2	65.1	10.9	14.9	15.0	12.2	12.2	19.5	4.3	31.6	4.0	59.4	64.0

Test truck speeds varied by 10 mph, from 59 to 69 mph. The measured post-validation pavement temperatures varied 18.2 degrees Fahrenheit, from 14.4 to 32.6. The mostly cloudy weather conditions prevented the desired 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 22-Dec-10

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	-0.2 ± 5.1%	Pass
Tandem Axles	±15 percent	-0.4 ± 3.4%	Pass
GVW	±10 percent	-0.3 ± 2.4%	Pass
Vehicle Length	±3 percent (1.9 ft)	-0.2 ± 1.1 ft	Pass
Axle Length	± 0.5 ft [150mm]	-0.1 ± 0.3 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement for all speeds was -0.1 ± 1.6 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of -0.1 feet, and the speed and axle spacing length measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.3.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relation exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 70 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-13 below.

Table 5-13 – Post-Validation Results by Speed – 22-Dec-10

Parameter	95% Confidence Limit of Error	Low 59.0 to 62.3 mph	Medium 62.4 to 65.8 mph	High 65.9 to 69.0 mph
Steering Axles	±20 percent	0.9 ± 5.5%	-0.3 ± 5.4%	-1.2 ± 4.8%
Tandem Axles	±15 percent	-0.3 ± 3.2%	-0.8 ± 3.8%	0.0 ± 3.6%
GVW	±10 percent	-0.2 ± 2.4%	-0.6 ± 3.0%	-0.2 ± 2.6%
Vehicle Length	±3 percent (1.9 ft)	-0.1 ± 1.1 ft	-0.2 ± 1.2 ft	-0.2 ± 1.4 ft
Vehicle Speed	± 1.0 mph	0.3 ± 1.0 mph	-0.2 ± 2.5 mph	-0.4 ± 1.4 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.4 ft	-0.1 ± 0.3 ft	-0.1 ± 0.2 ft

From the table, it can be seen that the WIM equipment estimates all weights with reasonable accuracy and the range of errors is consistent at all speeds. There does not appear to be a relationship between weight estimates and speed at this site.

To aid in the speed analysis, several graphs were developed to illustrate the possible effects of speed on GVW, single axle, and axle group weights, and axle and overall length distance measurements, as discussed in the following paragraphs.

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-11, the equipment estimated GVW with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range. Distribution of errors is shown graphically in the figure.

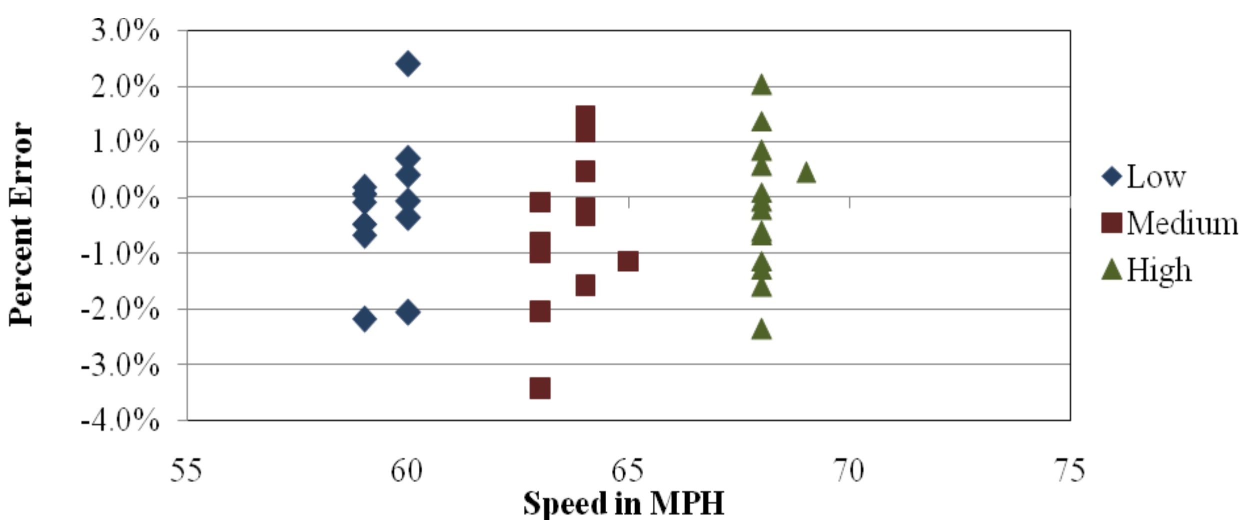


Figure 5-11 – Post-Validation GVW Errors by Speed – 22-Dec-10

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-12, the equipment estimated steering axle weights with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range. Distribution of errors is shown graphically in the figure.

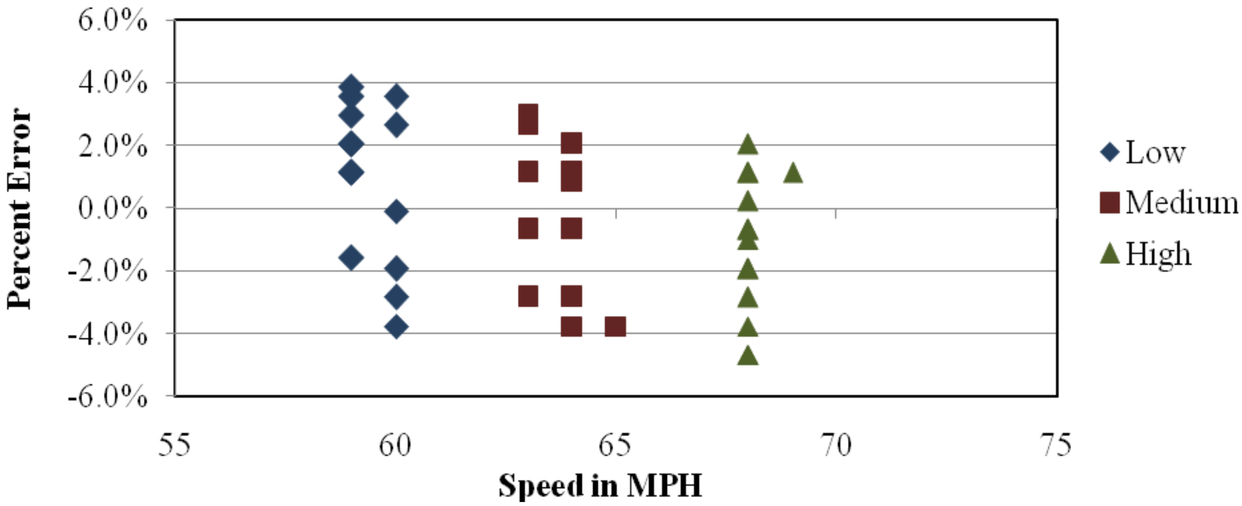


Figure 5-12 – Post-Validation Steering Axle Weight Errors by Speed – 22-Dec-10

5.3.1.3 Tandem Axle Weight Errors by Speed

As shown in Figure 5-13, the equipment estimated tandem axle weights with reasonable accuracy at all speeds. The range in error and bias is similar throughout the entire speed range. Distribution of errors is shown graphically in the figure.

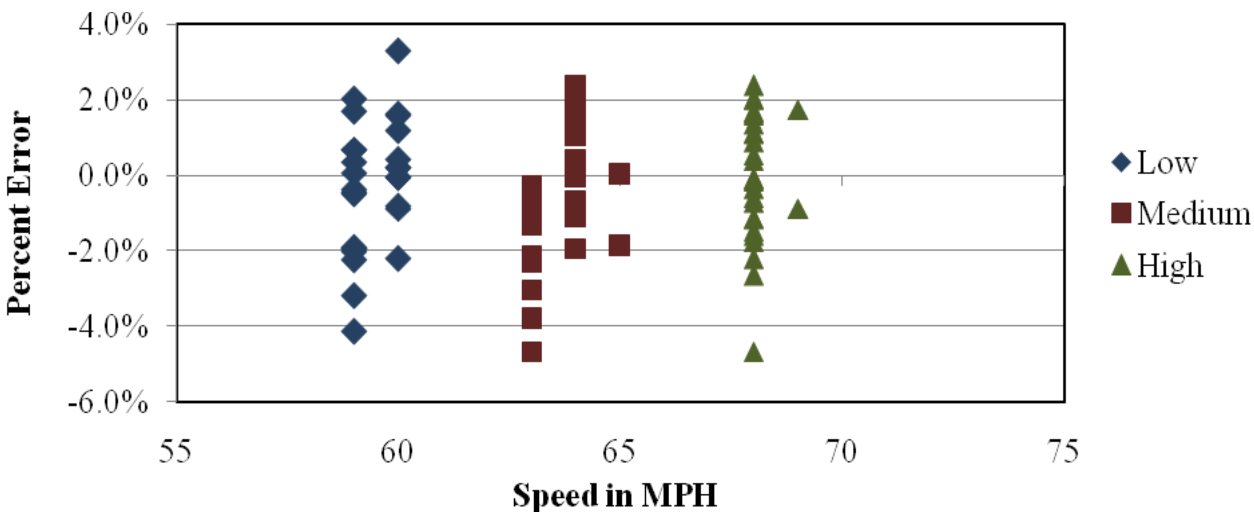


Figure 5-13 – Post-Validation Tandem Axle Weight Errors by Speed – 22-Dec-10

5.3.1.4 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-14 that when the GVW errors are analyzed by truck type, the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck for the low and medium speeds. GVW for the Primary truck is overestimated at the high speeds while GVW for the Secondary truck is underestimated.

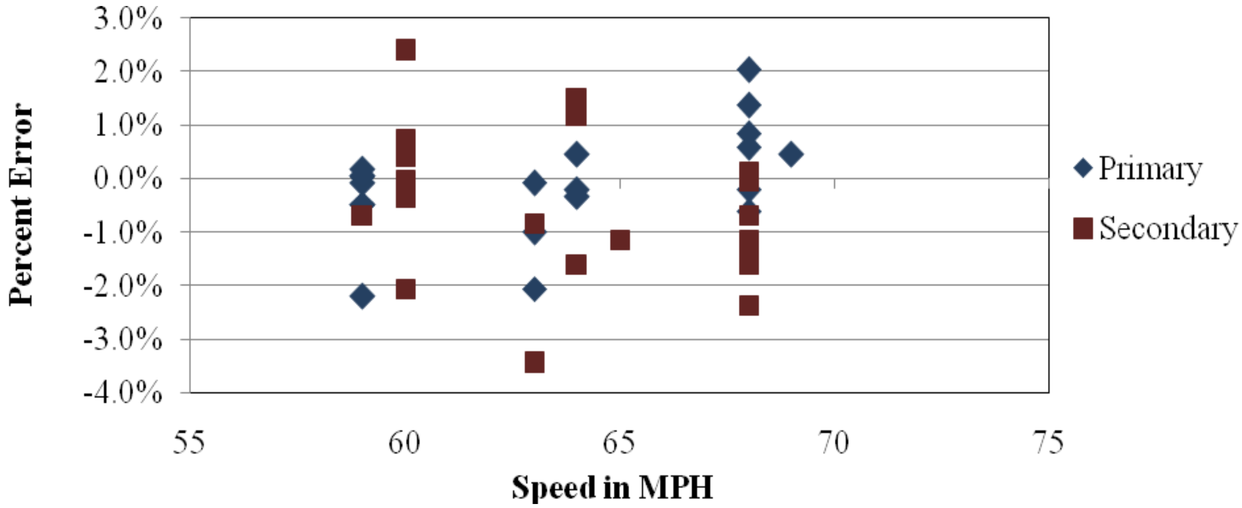


Figure 5-14 – Post-Validation GVW Error by Truck and Speed – 22-Dec-10

5.3.1.5 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error ranged from -0.3 feet to 0.3 feet. Distribution of errors is shown graphically in Figure 5-15.

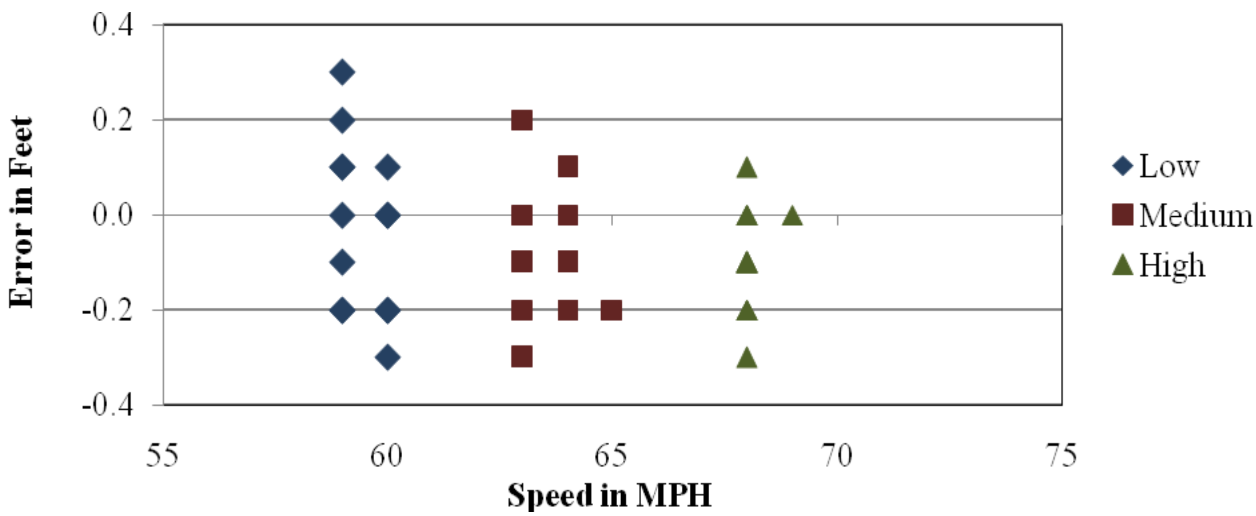


Figure 5-15 – Post-Validation Axle Length Error by Speed – 22-Dec-10

5.3.1.6 Overall Length Errors by Speed

For this system, the WIM equipment measures overall length consistently over the entire range of speeds, with errors ranging from -1.0 to 0.5 feet. Distribution of errors is shown graphically in Figure 5-16.

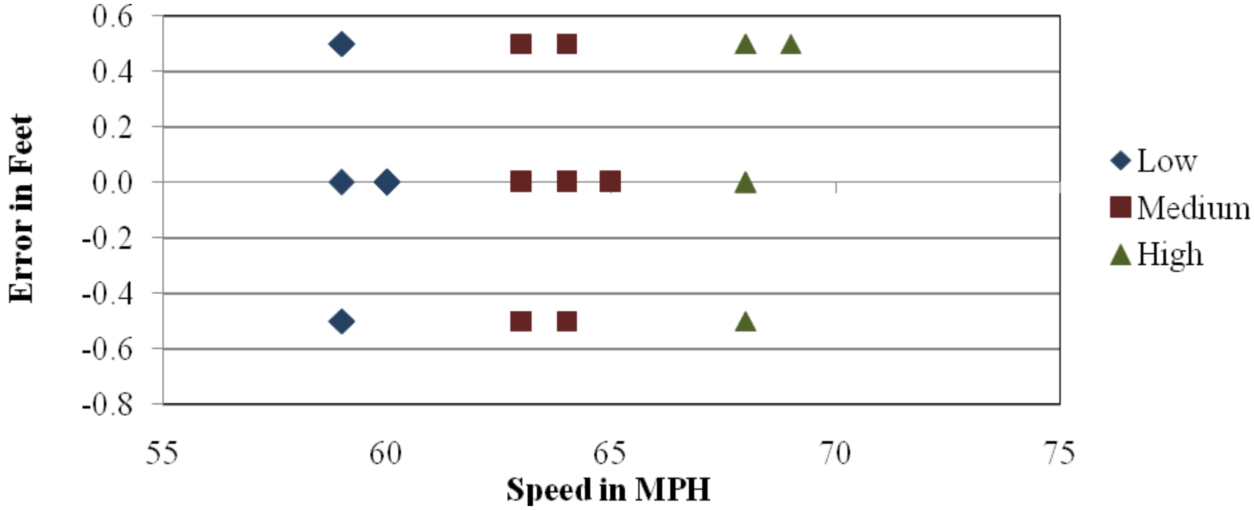


Figure 5-16 – Post-Validation Overall Length Error by Speed – 22-Dec-10

5.3.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether there is a relation between pavement temperature and WIM equipment weight and distance measurement accuracy. The range of pavement temperatures varied by 18.2 degrees, from 14.4 to 32.6 degrees Fahrenheit. The post-validation test runs are being reported under two temperature groups as shown in Table 5-14 below.

Table 5-14 – Post-Validation Results by Temperature – 22-Dec-10

Parameter	95% Confidence Limit of Error	Low	High
		14.4 to 23.5 degF	23.6 to 32.7 degF
Steering Axles	+20 percent	-0.1 ± 5.1%	-0.3 ± 5.7%
Tandem Axles	+15 percent	-0.6 ± 3.3%	0.0 ± 3.8%
GVW	+10 percent	-0.5 ± 2.6%	0.0 ± 2.4%
Vehicle Length	+3 percent (1.9 ft)	0.0 ± 1.1 ft	-0.3 ± 1.3 ft
Vehicle Speed	± 1.0 mph	-0.3 ± 1.8 mph	0.2 ± 1.4 mph
Axle Length	+ 0.5 ft [150mm]	0.0 ± 0.3 ft	-0.1 ± 0.2 ft

To aid in the analysis, several graphs were developed to illustrate the possible effects of temperature on GVW, single axle weights, and axle group weights.

5.3.2.1 GVW Errors by Temperature

From Figure 5-17, it can be seen that the equipment appears to estimate GVW with acceptable accuracy across the range of temperatures observed in the field. There appears to be a slight correlation between temperature and weight estimates where temperature causes weight estimates to rise as temperature rises.

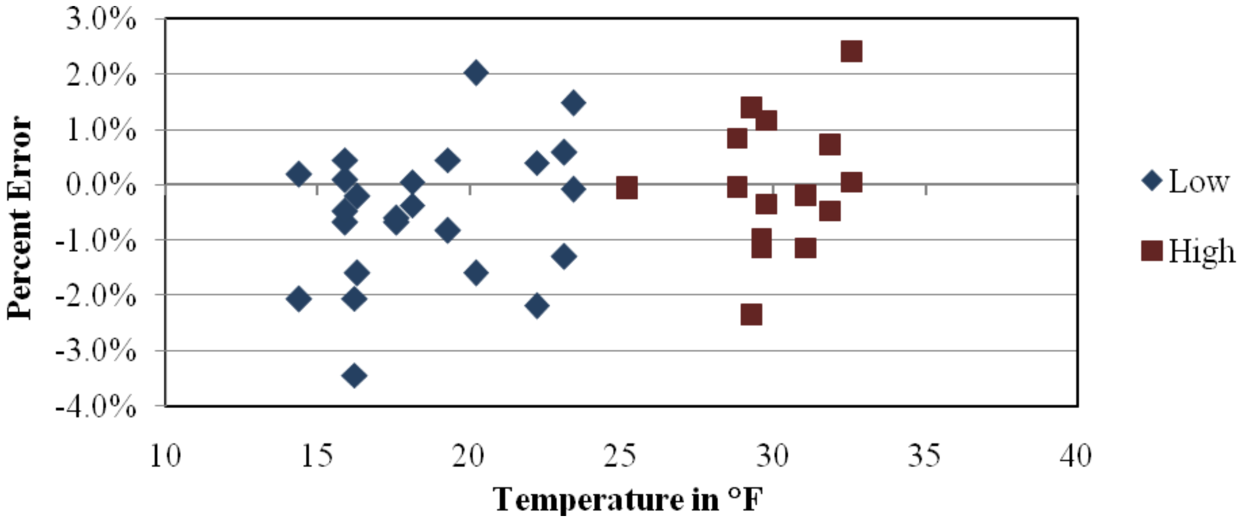


Figure 5-17 – Post-Validation GVW Errors by Temperature – 22-Dec-10

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-18 demonstrates that for steering axles, the WIM equipment appears to estimate with reasonable accuracy at all temperatures. The range in error is similar for different temperature groups.

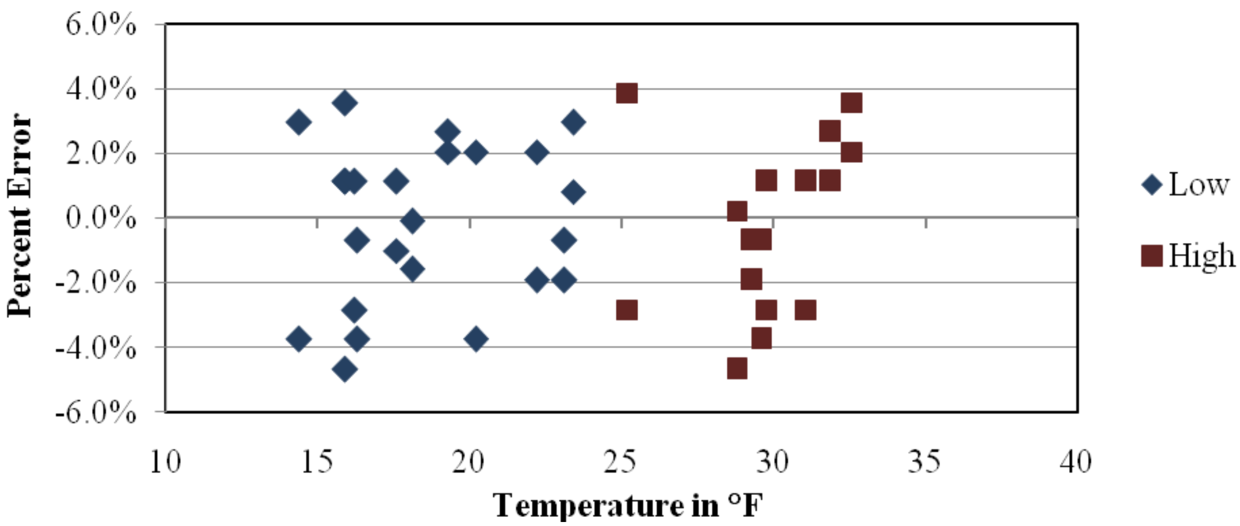


Figure 5-18 – Post-Validation Steering Axle Weight Errors by Temperature – 22-Dec-10

5.3.2.3 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-19, the equipment appears to estimate tandem axle weights with reasonable accuracy at all temperatures. The range in tandem axle errors is consistent for the two temperature groups.

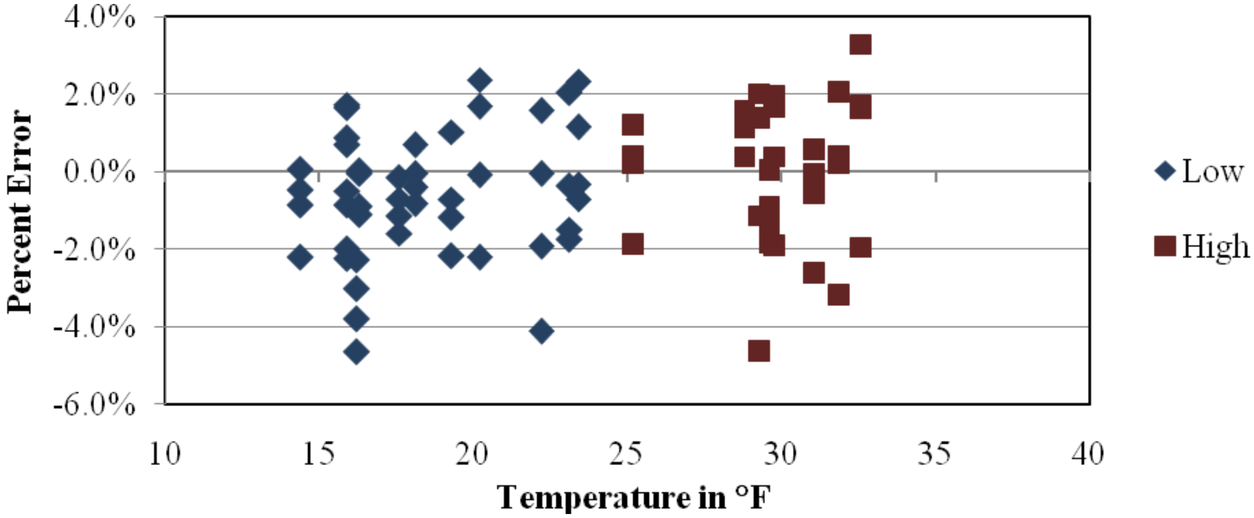


Figure 5-19 – Post-Validation Tandem Axle Weight Errors by Temperature – 22-Dec-10

5.3.2.4 GVW Errors by Temperature and Truck Type

As shown in Figure 5-20, when analyzed by truck type, GVW measurement errors for both trucks follow similar patterns. For both trucks, the range of errors and bias are reasonably consistent over the range of temperatures. Distribution of errors is shown graphically in the following figure.

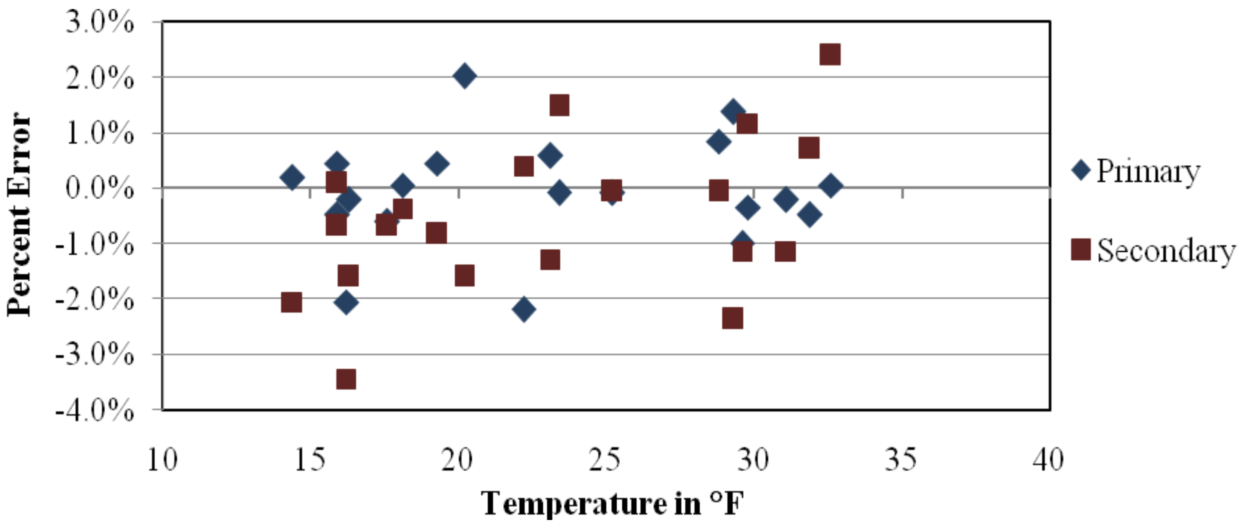


Figure 5-20 – Post-Validation GVW Error by Truck and Temperature – 22-Dec-10

5.3.3 Multivariable Analysis

This section provides additional analysis of post-validation results using a multivariable statistical technique of multiple linear regression. The same calibration data analyzed and discussed previously are analyzed again, but this time using a more sophisticated statistical methodology. The objective of the additional analysis is to investigate if the trends identified using previous analyses are statistically significant, and to quantify these trends.

Multivariable analyses provide additional insight on how speed, temperature, and truck type affect weight measurement errors for a specific site. It is expected that multivariable analyses done systematically for many sites will reveal overall trends.

5.3.3.1 Data

All errors from the weight measurement data collected by the equipment during the validation were analyzed. The percent error is defined as percentage difference between the weight measured by the WIM system and the static weight. Compared to analysis described previously, the weight of "axle group" was evaluated separately for tandem axles on tractors and on trailers. The separate evaluation was carried out because the tandem axles on trailers may have different dynamic response to loads than tandem axles on tractors. The measurement errors were statistically attributed to the following variables or factors:

- Truck type – Primary truck and secondary truck.
- Truck test speed – Truck test speed ranged from 59 to 69 mph.
- Pavement temperature – Pavement temperature ranged from 14.4 to 32.6 degrees Fahrenheit.
- Interaction between the factors such as the interaction between speed and pavement temperature.

5.3.3.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-15. The value of regression coefficients defines the slope of the relationship between the % error in GVW and the predictor variables (speed, temperature and truck type). The values of the t-distribution (for the regression coefficients) given in Table 5-15 are for the null hypothesis that assumes that the coefficients are equal to zero. The effects of speed and truck type were not statistically significant. The effect of temperature on GVW errors was significant at 7 percent level. In other words, the probability that the effect of temperature on the observed GVW errors occurred by chance alone is about 7 percent.

Table 5-15 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-2.4469	3.3147	-0.7382	0.4652
Speed	0.0092	0.0513	0.1794	0.8586
Temp	0.0567	0.0306	1.8521	0.0722
Truck	0.4702	0.3733	1.2595	0.2159

The relationship between temperature and the GVW measurement errors is shown in Figure 5-21. The figure includes a trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-21 provides quantification and statistical assessment of the relationship.

The quantification is provided by the value of the regression coefficient, in this case 0.0567 (in Table 5-15). This means, for example, that for a 10 degree increase in temperature, the % error is increased by about 0.6 % (0.0567 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient.

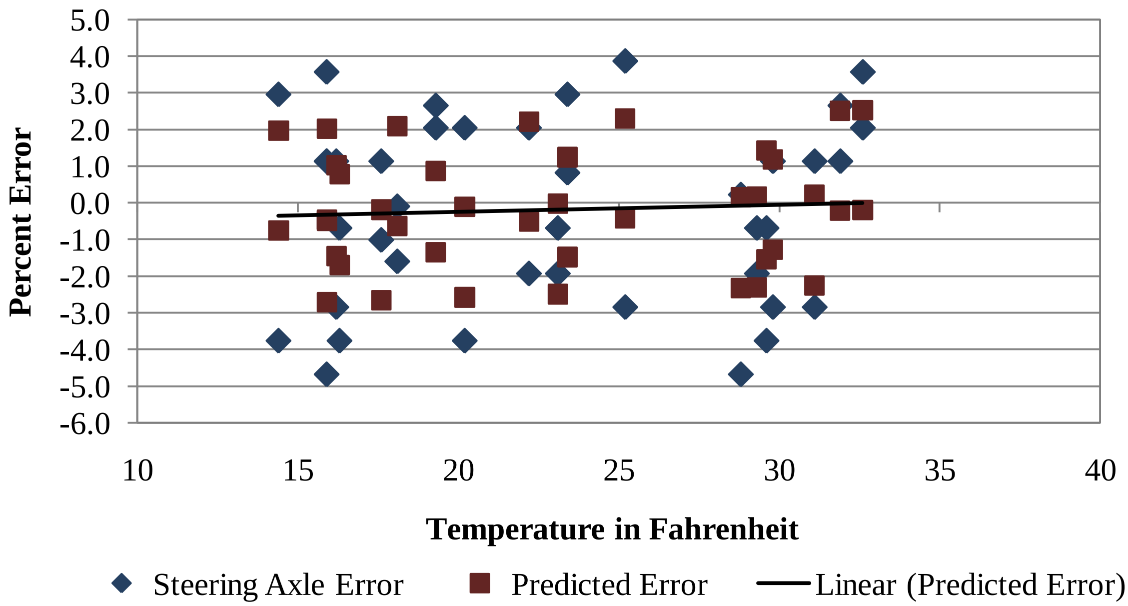


Figure 5-21 – Influence of Temperature on the Measurement Error of Steering Axle Weight

The effect speed on GVW was not statistically significant. The probability that the regression coefficient for speed (-0.0092 in Table 5-15) is not different from zero was 0.8586. In other words, the probability that the value of the regression coefficient is due to the chance alone is about 86 percent.

The interaction between speed, temperature, and truck type was investigated by adding an interactive variable (or variables) such as the product of speed and temperature. No interactive variables were statistically significant. The intercept was not statistically significant and does not have practical meaning.

5.3.3.3 Summary Results

Table 5-16 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Not listed in the table are factor interactions because the interactions were not statistically significant. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 5-16 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-16 – Summary of Regression Analysis

	Factor					
	Speed		**Temperature**		**Truck type**	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	-	-	0.0567	0.0722	-	-
Steering axle	-0.2510	0.0071	_	-	2.4720-	0.0004
Tandem axle tractor	0.1719	0.0241	0.0575	0.1950	-	-
Tandem axle trailer	-	-	0.0655	0.1130	-	-

5.3.3.4 Conclusions

1. Speed had statistically significant effect on measurement errors of steering axles and tandem axles on tractors.

2. Temperature may have statistically significant effect on the measurement error of GVW (at 7% significance level).

3. Truck type had statistically significant effect on the measurement error of steering axles only. The regression coefficient for truck type in Table 5-16, represent the difference between the mean errors for the primary and secondary trucks. (Truck type is an indicator variable with values of 0 or 1.). Thus, the mean error for steering axle weights for the secondary truck was about 2.5 % larger than the error for the primary truck.

4. Even though speed, temperature and truck type had statistically significant effect on some of the measurement errors, the practical significance of these factors is small and does not affect the validity of the calibration.

5.3.4 Classification and Speed Evaluation

The post-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the post-validation classification study at this site, a manual sample of 100 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field. Table 5-17 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study.

Table 5-17 – Post-Validation Classification Study Results – 22-Dec-10

Class	4	5	6	7	8	9	10	11	12	13
Observed Count	1	13	1	2	1	68	1	7	6	0
WIM Count	2	12	1	2	1	68	1	7	6	0
Observed Percent	1	13	1	2	1	68	1	7	6	0
WIM Percent	2	12	1	2	1	68	1	7	6	0
Misclassified Count	0	1	0	0	0	0	0	0	0	0
Misclassified Percent	0	8	0	0	0	0	0	0	0	N/A
Unclassified Count	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0	0	0	0	0	0	0	0	0	N/A

In the table above, the Misclassified Count represents the number of vehicles of a particular class that were visually observed as that class, but were not classified as the same type of vehicle by the equipment. As shown in the table, one class 5 vehicle was identified by the WIM equipment as a Class 4 vehicle, resulting in an undercount by the WIM equipment of one Class 5 vehicle and an overcount of one Class 4 vehicle – a misclassification of one Class 5 vehicle.

Misclassified vehicles are defined as those vehicles that are manually classified by observation as one type of vehicle but identified by the WIM equipment as another type of vehicle. The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-18.

Table 5-18 – Post-Validation Misclassifications by Pair – 22-Dec-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	0	5/9	0	9/5	0
3/8	0	6/4	0	9/8	0
4/5	0	6/7	0	9/10	0
4/6	0	6/8	0	10/9	0
5/3	0	6/10	0	10/13	0
5/4	1	7/6	0	11/12	0
5/6	0	8/3	0	12/11	0
5/7	0	8/5	0	13/10	0
5/8	0	8/9	0	13/11	0

Based on the vehicles observed during the post-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 1.0%.

As shown in the table, one vehicle, which included zero heavy trucks (6 – 13) was misclassified by the equipment. The misclassification was a Class 5 vehicle identified as a Class 4 vehicle by the equipment

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 22-Dec-10

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	0		

Based on the manually collected sample of the 100 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was -0.2 mph; the range of errors was 1.6 mph.

5.4 Post Visit Applied Calibration

The 85th percentile speed for trucks, based on the CDS data, is 71 mph, 1 mph above the posted speed limit of 70 mph and 1 mph above the highest test truck speed. Consequently, applied calibration will not be utilized to make recommendations for changes to the 65 to 75 mph speed point compensation factors.

Figure 5-22 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed. This provides a reasonable expectation for GVW errors above the test truck speeds.

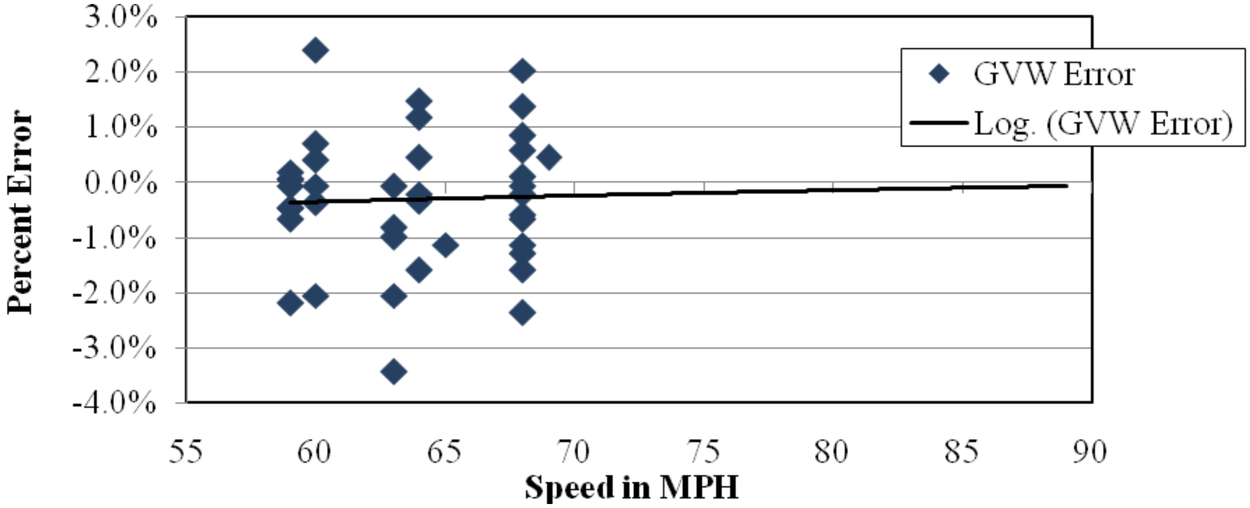


Figure 5-22 – GVW Error Trend

The starting calibration factors, all adjustments resulting from calibrations and the final factors left in place at the conclusion of the validation are provided in Table 5-20.

Table 5-20 – System Compensation Factors

Date	Speed Point	Start		Cal 1		Final	
12/22/2010		Left	Right	Left	Right	Left	Right
1	88	3258	3772	3156	3654	3156	3654
2	96	3494	4049	3385	3923	3385	3923
3	104	3428	3971	3344	3874	3344	3874
4	112	3440	3986	3370	3905	3370	3905
5	120	3509	4064	3437	3981	3437	3981
Dynamic/FA		100		101		101	
Distance		370		370		370	
Loop Width		250		320		320	

6 Previous WIM Site Validation Information

The information reported in this section provides a summary of the performance of the WIM equipment since it was installed. The information includes historical data on weight and classification accuracies as well as a comparison of post-validation results.

6.1 Sheet 16s

This site has validation information from two previous visits as well as the current one as summarized in the tables below. Table 6-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class										Pct Unclass
	4	5	6	7	8	9	10	11	12	13	
31-Oct-06	75	50	0	N/A	18	3	N/A	25	0	100	0
1-Nov-06	50	33	0	0	0	1	0	33	0	N/A	0
17-Apr-07	N/A	N/A	N/A	N/A	0	1	N/A	14	0	N/A	2
18-Apr-07	N/A	0	0	N/A	0	0	0	0	0	N/A	0
29-Jun-08	N/A	18	0	N/A	38	0	N/A	0	N/A	N/A	0
30-Jun-08	0	21	0	N/A	50	1	N/A	0	N/A	N/A	0
21-Dec-10	N/A	0	0	N/A	11	0	0	0	0	N/A	0
22-Dec-10	0	8	0	0	0	0	0	0	0	N/A	0

Table 6-2 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-2 – Weight Validation History

Date	Mean Error (95% Confidence)		
	GVW	Single Axles	Tandem
31-Oct-06	-1.2 (6.5)	-3.8 (9.5)	-1.8 (13.3)
1-Nov-06	-1.6 (4.6)	-4.8 (7.7)	-1.1 (5.8)
17-Apr-07	-1.5 (7.9)	-3.0 (17.5)	-1.2 (10.9)
18-Apr-07	0.5 (6.3)	-0.3 (10.7)	0.6 (9.2)
29-Jun-08	-2.4 (2.6)	-1.3 (4.9)	-2.6 (3.9)
30-Jun-08	0.8 (2.9)	2.5 (6.2)	0.5 (4.2)
21-Dec-10	2.5 (2.2)	1.6 (5.1)	2.7 (3.1)
22-Dec-10	-0.2 (2.4)	0.9 (5.5)	-0.3 (3.2)

The variability of the weight errors appears to have significantly fluctuated since the site was first validated. From this information, it appears that the system weight estimates demonstrate a tendency to drift over time. The table also demonstrates the effectiveness of the validations in bringing the weight estimations to within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

A comparison of the post-validation results from previous visits is provided in Table 6-3.

Table 6-3 – Comparison of Post-Validation Results

Parameter	95 %Confidence Limit of Error	Site Values (mean Error and 95% Confidence)			
		1-Nov-06	18-Apr-07	30-Jun-08	22-Dec-10
Single Axles	±20 percent	-4.8 ± 7.7	-0.3 ± 10.7	2.5 ± 6.2	-0.9 ± 5.5
Tandem Axles	±15 percent	-1.1 ± 5.8	0.6 ± 9.2	0.5 ± 4.2	-0.3 ± 3.2
GVW	±10 percent	-1.6 ± 4.6	0.5 ± 6.3	0.8 ± 2.9	-0.2 ± 2.4

From the table, it appears that the variance for all weights has decreased since the equipment was installed.

7 Additional Information

The following information is provided in the attached appendix:

- Site Photographs
  - Equipment
  - Test Trucks
  - Pavement Condition
- Pre-validation Sheet 16 – Site Calibration Summary
- Post-validation Sheet 16 – Site Calibration Summary
- Pre-validation Sheet 20 – Classification and Speed Study
- Post-validation Sheet 20 – Classification and Speed Study

Additional information is available upon request through LTPP INFO at ltppinfo@dot.gov, or telephone (202) 493-3035. This information includes:

- Sheet 17 – WIM Site Inventory
- Sheet 18 – WIM Site Coordination
- Sheet 19 – Calibration Test Truck Data
- Sheet 21 – WIM System Truck Records
- Sheet 22 – Site Equipment Assessment plus Addendum
- Sheet 24A/B – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

Kansas, SPS-2
SHRP ID: 200200

Validation Date: December 22, 2010

APPLIED RESEARCH ASSOCIATES, INC.


Photo 1 – Cabinet Exterior


Photo 2 – Cabinet Interior (Front)


Photo 3 – Cabinet Interior (Back)


Photo 4 – Leading Loop


Photo 5 – Leading WIM Sensor


Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop

Photo 8 – Power Meter

Photo 9 – Telephone Drop

Photo 10 – Telephone Pedestal

Photo 11 – Downstream

Photo 12 – Upstream

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 20 SPS WIM ID: 200200 DATE (mm/dd/yyyy) 12/21/2010

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 12/21/10

2. **TYPE OF EQUIPMENT CALIBRATED:** Both

3. **REASON FOR CALIBRATION:** LTPP Validation

4. **SENSORS INSTALLED IN LTPP LANE AT THIS SITE** (Select all that apply):
   a. Inductance Loops
   b. Bending Plates
   c.
   d.

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. **CALIBRATION TECHNIQUE USED:** Test Trucks

Number of Trucks Compared:
Number of Test Trucks Used: 2
Passes Per Truck: 20

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	air	air
Truck 3:	0	0	0

7. **SUMMARY CALIBRATION RESULTS** (expressed as a %):

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	2.5%	Standard Deviation:	1.1%
Dynamic and Static Single Axle:	1.6%	Standard Deviation:	2.5%
Dynamic and Static Double Axles:	2.7%	Standard Deviation:	1.5%

8. **NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED:** 3

9. **DEFINE SPEED RANGES IN MPH:**

			Low		High	Runs
a.	Low	-	59.0	to	62.3	13
b.	Medium	-	62.4	to	65.8	14
c.	High	-	65.9	to	69.0	13
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 20 SPS WIM ID: 200200 DATE (mm/dd/yyyy) 12/21/2010

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3370 | 3905

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

The Auto-cal feature is using a linear progression of numerical values, starting at 1000 for 0 degrees, with a value incremented by 4 for every degree up to 100 degrees.

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:		FHWA Class		-	
FHWA Class 8:		FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Pre

Person Leading Calibration Effort: **Dean J. Wolf**

Contact Information: Phone: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 20 SPS WIM ID: 200200 DATE (mm/dd/yyyy) 12/22/2010

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 12/22/10

2. **TYPE OF EQUIPMENT CALIBRATED:** Both

3. **REASON FOR CALIBRATION:** LTPP Validation

4. **SENSORS INSTALLED IN LTPP LANE AT THIS SITE** (Select all that apply):
   a. Inductance Loops
   b. Bending Plates
   c.
   d.

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. **CALIBRATION TECHNIQUE USED:** Test Trucks

   Number of Trucks Compared:
   Number of Test Trucks Used: 2
   Passes Per Truck: 20

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	air	air
Truck 3:	0	0	0

7. **SUMMARY CALIBRATION RESULTS** (expressed as a %):

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	-0.3%	Standard Deviation:	1.2%
Dynamic and Static Single Axle:	-0.2%	Standard Deviation:	2.5%
Dynamic and Static Double Axles:	-0.4%	Standard Deviation:	1.7%

8. **NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED:** 3

9. **DEFINE SPEED RANGES IN MPH:**

			Low		High	Runs
a.	Low	-	59.0	to	62.3	14
b.	Medium	-	62.4	to	65.8	12
c.	High	-	65.9	to	69.0	14
d.		-		to		
e.		-		to		

Traffic Sheet 16	STATE CODE:	20
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	200200
SITE CALIBRATION SUMMARY	DATE (mm/dd/yyyy)	12/22/2010

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3377 | 3913

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

The Auto-cal feature is using a linear progression of numerical values, starting at 1000 for 0 degrees, with a value incremented by 4 for every degree up to 100 degrees.

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	______	FHWA Class	______	-	______
FHWA Class 8:	______	FHWA Class	______	-	______
		FHWA Class	______	-	______
		FHWA Class	______	-	______

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort: **Dean J. Wolf**

Contact Information: Phone: 717-512-6638

E-mail: dwolf@ara.com

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 20 SPS WIM ID: 200200 DATE (mm/dd/yyyy) 12/21/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
68	9	28025	68	9	53	5	28175	52	5
70	9	28032	69	9	68	9	28181	69	9
64	6	28034	64	6	70	9	28186	70	9
64	9	28035	64	9	61	9	28187	62	9
68	5	28042	69	5	64	9	28190	64	9
70	6	28048	70	6	70	9	28201	70	9
68	5	28056	69	5	72	9	28202	71	9
67	9	28061	66	9	71	9	28206	70	9
71	9	28064	71	9	65	9	28207	64	9
69	9	28065	69	9	75	5	28208	75	5
68	5	28079	68	5	70	5	28215	70	5
71	5	28094	70	5	71	9	28216	71	9
70	9	28095	70	9	68	9	28219	70	9
61	5	28102	66	5	70	9	28220	69	9
71	9	28115	71	9	71	9	28221	71	9
70	9	28118	71	9	61	8	28222	60	8
69	9	28124	68	9	64	9	28230	65	9
69	9	28127	69	9	62	8	28247	62	8
69	9	28133	69	9	**68**	**5**	**28260**	**68**	**8**
67	9	28135	68	9	62	5	28266	64	5
74	5	28138	74	5	62	11	28267	65	11
69	9	28151	68	9	64	9	28278	63	9
67	11	28156	67	11	73	9	28279	74	9
69	9	28160	66	9	64	9	28299	68	9
69	9	28162	60	9	74	9	28308	73	9

Sheet 1 - 0 to 50 Start: 15:37:00 Stop: 16:12:42

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 20 SPS WIM ID: 200200 DATE (mm/dd/yyyy) 12/21/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
70	9	28309	71	9	65	8	28449	66	8
69	9	28310	68	9	62	9	28458	62	9
61	9	28316	62	9	61	8	28472	62	8
61	9	28317	61	9	75	5	28474	75	5
65	9	28318	65	9	63	9	28482	63	9
64	9	28319	68	9	68	8	28488	69	8
69	5	28329	68	5	62	9	28491	62	9
69	9	28330	70	9	62	9	28494	68	9
65	9	28334	65	9	67	5	28499	68	5
70	9	28352	70	9	69	9	28515	70	9
64	9	28360	65	9	62	5	28541	62	5
61	9	28361	62	9	68	9	28544	68	9
72	9	28367	73	9	68	9	28563	68	9
68	9	28371	66	9	68	5	28567	68	5
74	10	28377	74	10	61	8	28573	63	8
68	9	28383	71	9	67	9	28576	69	9
67	9	28387	66	9	72	9	28577	70	9
63	9	28390	62	9	60	9	28578	60	9
71	9	28410	71	9	72	9	28587	70	9
75	9	28411	75	9	69	9	28588	69	9
62	9	28414	63	9	66	9	28589	67	9
65	9	28420	65	9	68	8	28598	69	8
68	9	28435	68	9	69	12	28599	68	12
65	9	28440	65	9	68	8	28609	68	8
64	9	28442	65	9	70	9	28615	69	9

Sheet 2 - 51 to 100 Start: 16:12:56 Stop: 16:45:32

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Pre

Traffic Sheet 20	STATE CODE:	20
LTPP MONITORED TRAFFIC DATA	SPS WIM ID:	200200
SPEED AND CLASSIFICATION STUDIES	DATE (mm/dd/yyyy)	12/22/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
66	5	31917	67	5	68	9	32056	68	9
62	9	31921	62	9	68	4	32065	68	4
62	11	31922	62	11	63	9	32072	63	9
66	9	31923	66	9	69	9	32073	69	9
67	9	31932	67	9	61	11	32074	60	11
64	11	31933	64	11	67	9	32075	67	9
61	9	31952	62	9	60	9	32077	64	9
69	9	31956	68	9	69	5	32082	71	5
75	5	31963	73	5	68	9	32083	68	9
64	9	31966	65	9	62	9	32085	63	9
65	5	31967	64	5	68	9	32090	68	9
64	9	31979	64	9	68	5	32092	68	5
69	9	31986	69	9	70	9	32098	69	9
69	9	31988	69	9	72	5	32100	70	5
69	6	31992	69	6	62	9	32103	62	9
64	9	31996	64	9	65	9	32104	65	9
64	7	31998	64	7	64	11	32105	68	11
63	7	31999	65	7	72	9	32112	72	9
67	9	32012	66	9	62	9	32113	61	9
63	10	32016	69	10	67	9	32117	67	9
60	9	32023	60	9	65	9	32118	66	9
69	5	32027	70	5	65	9	32119	65	9
64	11	32030	65	11	64	11	32120	64	11
75	9	32037	68	9	70	9	32121	70	9
67	9	32038	70	9	68	9	32122	69	9

Sheet 1 - 0 to 50 Start: 8:54:40 Stop: 9:24:05

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 20 SPS WIM ID: 200200 DATE (mm/dd/yyyy) 12/22/2010

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
68	9	32868	67	9	66	12	32999	65	12
67	5	32873	67	5	64	12	33000	63	12
59	9	32877	62	9	66	9	33001	65	9
67	9	32878	67	9	73	12	33006	71	12
68	9	32886	69	9	66	9	33011	65	9
68	9	32896	68	9	57	9	33019	58	9
67	9	32901	67	9	**62**	**4**	**33037**	**64**	**5**
62	9	32902	62	9	67	9	33038	67	9
71	9	32914	72	9	66	9	33047	66	9
66	9	32922	69	9	69	9	33049	69	9
70	9	32923	70	9	70	9	33050	69	9
82	5	32928	81	5	62	9	33058	63	9
64	9	32935	69	9	70	9	33063	71	9
70	8	32938	70	8	64	9	33074	67	9
65	9	32940	64	9	68	9	333076	66	9
68	9	32946	67	9	70	9	33082	70	9
69	12	32950	68	12	70	9	33083	69	9
71	9	32961	71	9	65	12	33085	66	12
66	9	32968	65	9	67	11	33086	67	11
72	5	32970	73	5	67	9	33094	67	9
69	12	32978	69	12	72	9	33096	73	9
70	9	32984	69	9	71	5	33102	70	5
64	9	32986	64	9	66	9	33103	67	9
69	9	32992	67	9	72	9	33104	71	9
65	9	32997	66	9	67	5	33121	70	5

Sheet 2 - 51 to 100 Start: 11:08:00 Stop:

Recorded By: kt Verified By: djw

Validation Test Truck Run Set - Post